POWER PLANT ENGINEERING

Established Over 30 Years

VOL. XXX CHICAGO, SEPTEMBER 15, 1926. No. 18

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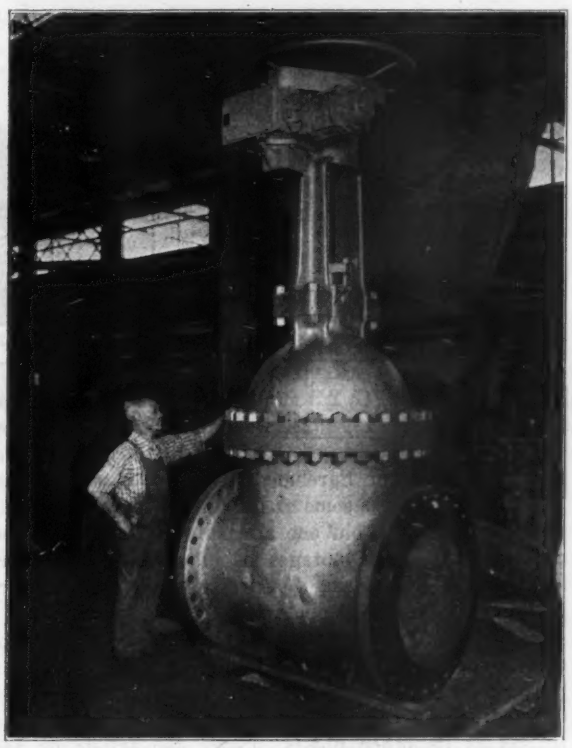


The Seven-League Gloves

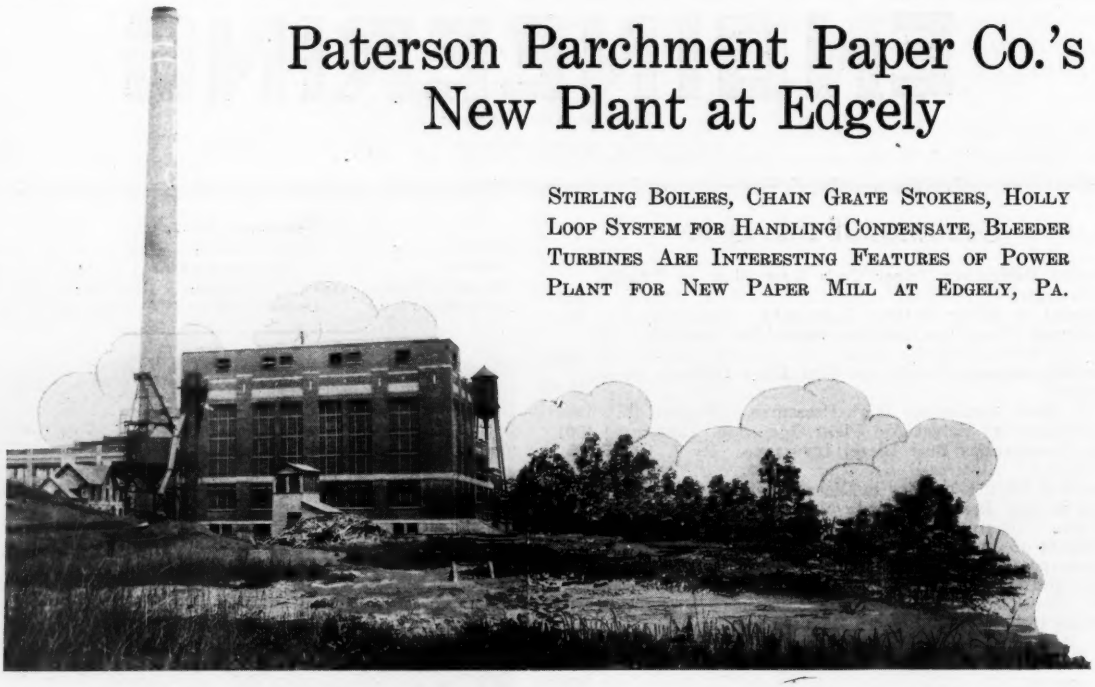
ONCE UPON A TIME, so the tale tells, there was a power plant engineer who had a kind and indulgent fairy godmother. She used to come in her 10-mouse-power Pumpkin sedan, bringing him all sorts of nice automatic dooflickers and gadgets to put on his equipment, so that his plant almost operated itself.

And the tale tells how the chief, in spite of all this, wished that he had an extension to put on his arm so that he could reach all over the plant, without moving from his office, to open and close all the valves. So his fairy godmother got him a pair of seven-league gloves, similar to the famous seven-league boots.

We happen to know this lucky engineer and can take you to see him, if you like. Of course, when he talks to you about his motor-operated valves, such as the one shown above and the ones discussed elsewhere in this issue, that's one thing. But it's quite another thing when you see him reach out his hand, touch a button and close a valve 200 ft. away in the boiler room. When you see that, you will certainly not have any doubts about his kind fairy godmother and her wonderful present of the seven-league gloves.

Paterson Parchment Paper Co.'s New Plant at Edgely

STIRLING BOILERS, CHAIN GRATE STOKERS, HOLLY LOOP SYSTEM FOR HANDLING CONDENSATE, BLEEDER TURBINES ARE INTERESTING FEATURES OF POWER PLANT FOR NEW PAPER MILL AT EDGELY, PA.



JUST TWO YEARS ago, in the issue of September 15, 1924, we published an article on the Methods of Operation at the plant of the Paterson Parchment Paper Co., at Passaic, N. J. As some of the readers may recall, this plant, although an old one and subject to some of the constructional disadvantages of old plants, was characterized by engineering features of high quality, particularly as concerned operation.

This company, which manufactures a vegetable parchment paper used in the wrapping of foods or similar purposes, has several plants, the one at Passaic being devoted to the chemical treatment of paper manufacturned at its other plants. Since the article on the Passaic plant was published in 1924, a new paper mill has been erected at Edgely, Pa., on the main line of the Pennsylvania Railroad between Trenton and Philadelphia. This mill, which includes a power plant, has been completed and is now in operation.

As might be expected, the new power plant at Edgely reflects the experience and knowledge gained in the operation of the Passaic plant. All the features which have proved desirable at Passaic have been incorporated in the Edgely plant and a number of new ones added. The system of keeping records is also similar to that at Passaic, and has been found of great value in maintaining high efficiency.

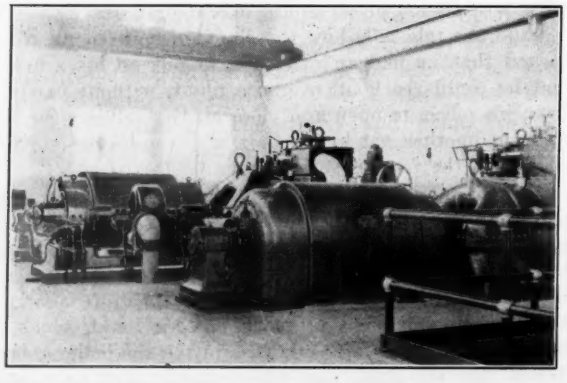


FIG. 1. TWO BLEEDER-TYPE TURBO-GENERATORS GENERATE ALL ELECTRICAL ENERGY USED IN THE MILL

The power plant, which was designed by Abbott, Merkt & Co., Inc., of New York, and which furnishes the paper mill with all power, light, heat and water, is located at one end of the mill group, several hundred feet from the bank of the Delaware River. The buildings are of brick, steel and concrete, with red pressed brick facing and concrete trimmings. A 230-ft. radial brick chimney, 12 ft. inside diameter at the bottom and 8 ft. at the top, built by the American Chimney Corporation, also of red brick, is mounted on a separate foundation about 20 ft. from the buildings. Adjacent to the power plant is a coal storage yard where approximately 6000 t. of coal are kept on hand at all times, and from which coal is reclaimed by a drag scraper. Water for boiler feed and condensing purposes, as well as for the paper mill supply, is drawn from the Delaware River.

FEATURES OF THE BOILER ROOM

The boiler room is rectangular in shape, 102 ft. long and 53 ft. wide, with the boilers arranged in one row with their backs toward the dividing wall between the turbine and boiler room. The boilers are set in batteries of two and the feed pump and heaters are located at one end of the room. The turbine and boiler room floors are on the same level. Excellent natural illumination is provided, not only in the boiler room but in the turbine room and basement as well, by large windows on all sides of the building.

Steam for all purposes is generated in four Stirling boilers built by the Babcock and Wilcox Co., each hav-

ing 6118 sq. ft. of heating surface and fitted with Foster superheaters. These units which are rated at 612 hp. and operate at a steam pressure of 175 lb. with 100-deg. superheat are provided with the following equipment: Crane safety valves, Yarway blowoff valves, six units of Diamond soot blowers, Reliance water columns with high and low water alarms, Ellison draft gages and the Engineer Co. system of balanced draft.

Superheated steam is used only in the main turbines and in the reciprocating engines in the paper mill. All steam-operated auxiliaries in the power plant are run on saturated steam taken from the boilers through a separate header.

The Coxe chain grate stokers are fitted for forced draft operation and are driven by 3 by 4-in. vertical engines of American Blower Co. manufacture. The latter are located at the rear and at the side of the boilers and connect to the stoker drive shafts by belt. Forced draft is furnished by four Sirocco blowers direct connected to 6 by 6-in. vertical engines, the entire installation being made by the American Blower Co. The fans are located in the basement below the boiler room firing aisle and connect to the stoker wind boxes by short steel ducts.

Handling Coal

Coal delivered to the plant is sent either to the storage pile or to the overhead bunkers in the boiler room, depending upon whether it is to be kept in reserve or intended for immediate use. If it is intended for reserve, it is dumped into the track hopper located at the side of the boiler house and then by means of an apron conveyor and a vertical bucket-elevator is carried up the outside boiler room wall to approximately the roof level, from which point it discharges through a spout by gravity to a point on the ground level opposite the track hopper. From here, a Beaumont drag scraper, driven by a 25-hp. motor carries it to any point in the storage yard.

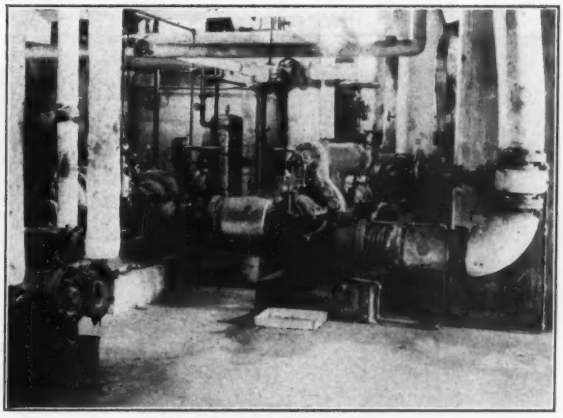


FIG. 2. A CORNER IN THE TURBINE ROOM BASEMENT

In reclaiming from the storage pile, this same drag scraper removes the coal from the pile and delivers it directly to the track hopper for further delivery to the overhead bunkers.

Coal for immediate use is carried from the track hopper to the top of the boiler house by the apron conveyor and the bucket-elevator already referred to, but from this point, the route changes. Instead of passing to the downspout in the manner previously described, it is delivered to a distributor conveyor installed above the overhead coal bunkers.

The coal bunkers are of the elliptical type made of steel, lined with Bitumastic and have a capacity of about 500 t. From the bunkers the coal falls by gravity into

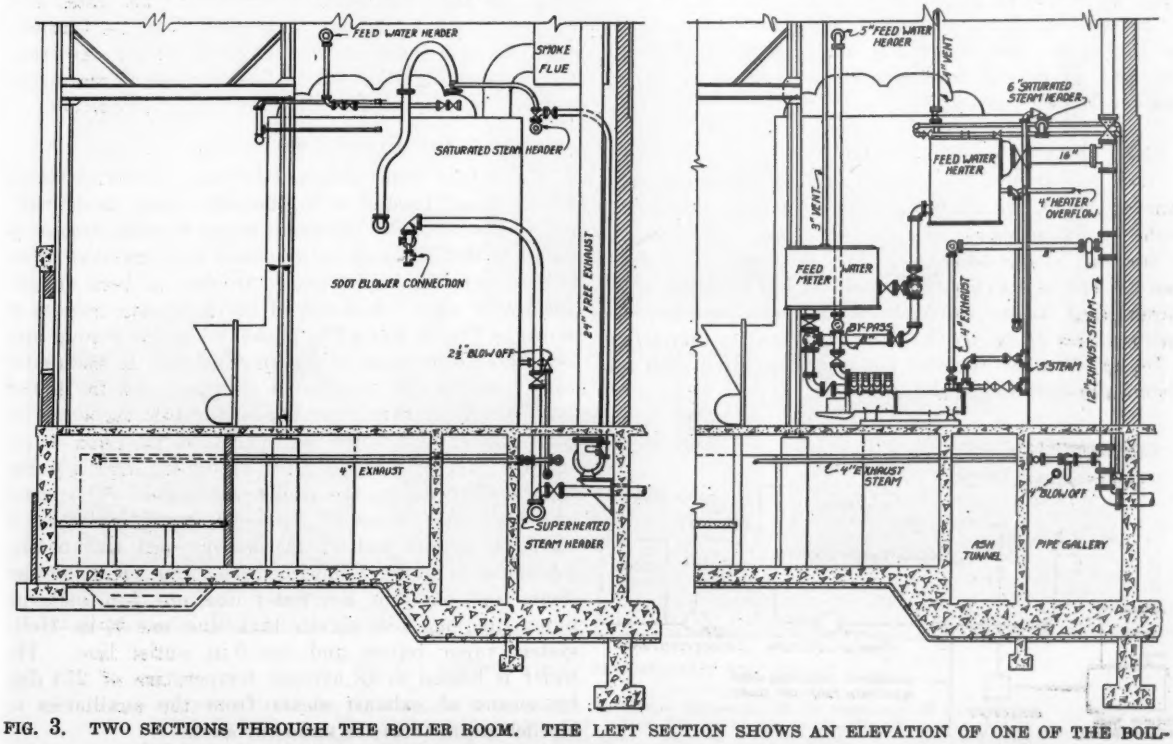


FIG. 3. TWO SECTIONS THROUGH THE BOILER ROOM. THE LEFT SECTION SHOWS AN ELEVATION OF ONE OF THE BOILERS, WHILE THE RIGHT SHOWS THE ARRANGEMENT OF FEEDWATER HEATER, PUMPS AND METER

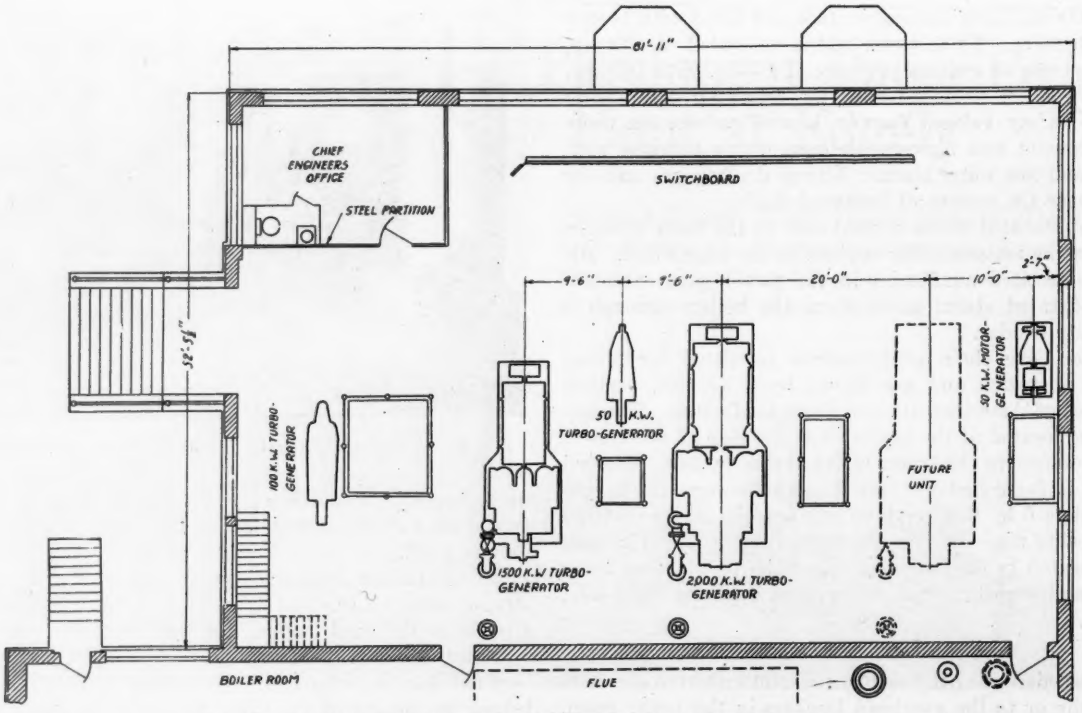


FIG. 4. PLAN OF TURBINE ROOM SHOWING LOCATION OF EQUIPMENT

Richardson, self-balancing scales and then to the stoker hoppers. Each stoker feed spout is equipped with its individual scale, these being driven by ½-hp. Holtzer-Cabot motors and having a dumping capacity of 200 lb. The delivery of coal from the bunkers through the coal scales and into the stoker hoppers is controlled by cables from the operating floor.

All coal-handling equipment with the exception of the Richardson coal scales was made by the Beaumont Co. and is driven throughout by 3-phase, 60-cycle Crocker Wheeler motors.

Ash Disposal

Ash is delivered by gravity into an industrial car running below the ash gates which, in turn, carries it to the receiving hopper of a Beaumont skip hoist located at one end of the basement. This skip hoist then carries the ash to a cylindrical steel ash bin in which it is stored until it can be removed from the premises by railroad cars or by truck. The skip hoist is driven by a 7½-hp. Crocker Wheeler motor and is fitted with an electrically-operated brake.

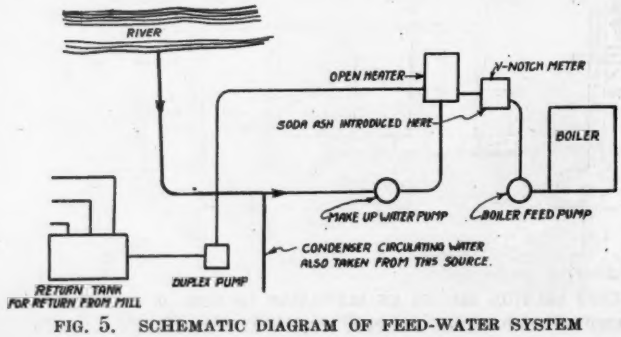


FIG. 5. SCHEMATIC DIAGRAM OF FEED-WATER SYSTEM

In connection with the ash-handling system, an interesting arrangement has been provided to eliminate the intense draft caused when the ash gates are opened for the removal of ashes. This draft is not only extremely annoying to the operator but disturbs combustion conditions in the furnace. By means of a damper, controlled from the point at which the ash gates are operated, the ash pits can be isolated from the furnace while the ash gates are opened and the ash removed, thus eliminating the draft. The damper is manually operated by means of a cable running over pulleys.

Feed-Water System

Boiler feed water obtained from the Delaware River is filtered and treated with lime-soda before its delivery into the boilers. No elaborate water treating system is installed, the lime-soda being added just previous to its delivery into the boiler, but no trouble has been experienced with scale. A sketch of the feed-water system is shown in Fig. 5, while Fig. 3 shows how the piping and feed-water equipment is actually installed in the boiler room. Water for circulating purposes and for boiler feed, it will be noted, are drawn through the same intake. Boiler feed water is drawn from the common intake by a 7½ by 6 by 10-in. Worthington, duplex pump and discharged into the feed-water heater. The latter is a Cochrane heater of the open type, located on a platform at one end of the boiler room and having connected to it the following lines: one 16-in. bleeder steam line, one 3-in. hot water line, one 3-in. make-up pump line, one 3-in. service tank line, one ¾-in. Holly system vapor return and one 8-in. outlet line. The water is heated to an average temperature of 215 deg. by means of exhaust steam from the auxiliaries or bleeder steam from the main turbines.

After being heated the water is metered by a Coch-

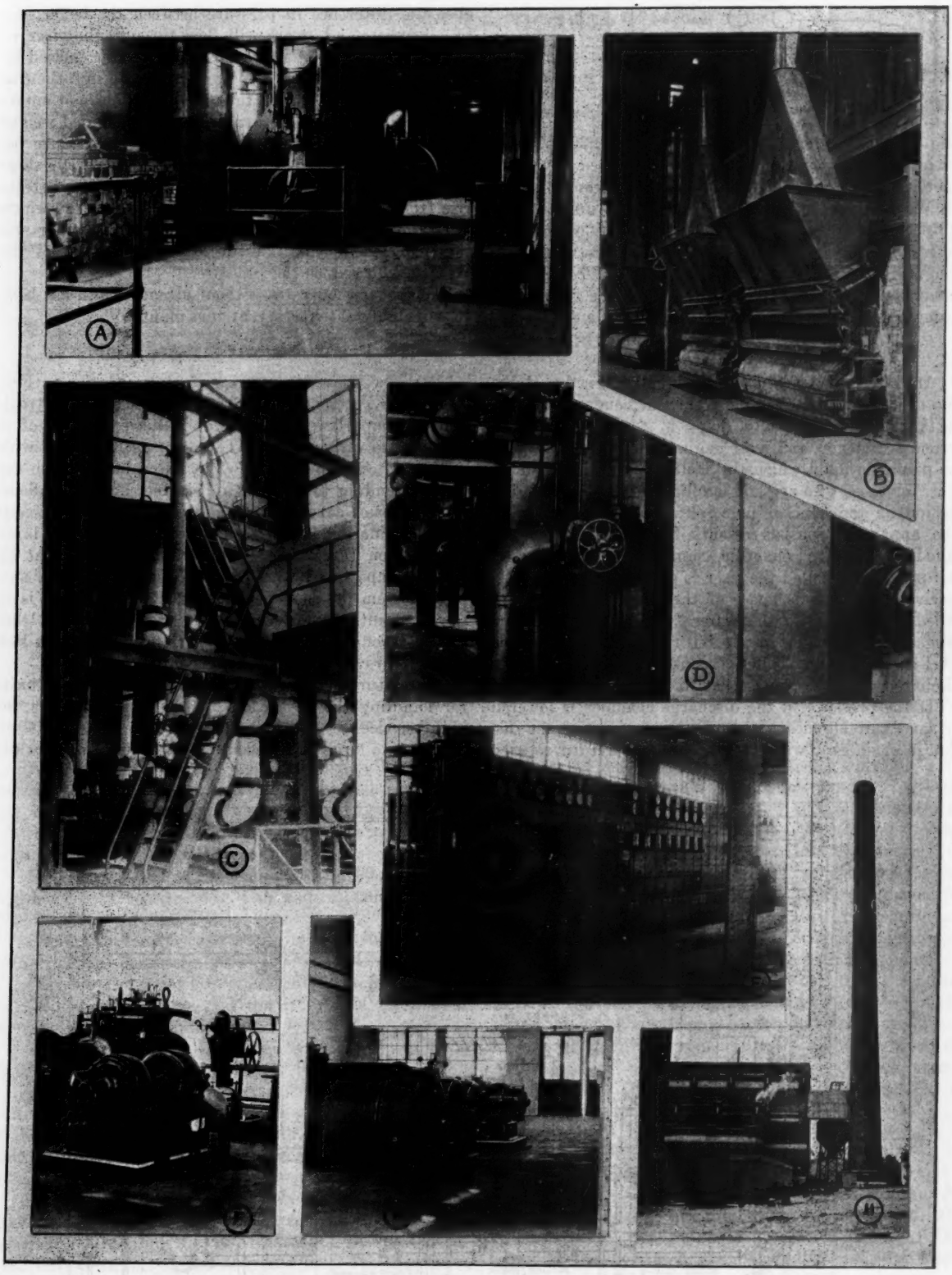


FIG. 6. VARIOUS VIEWS THROUGHOUT THE PLANT

A, Forced draft for the furnaces is furnished by these blowers. B, A close-up of the chain grate stokers. C, The feed-water heater and meter are mounted on platforms in the boiler room. D, Circulating water piping in the basement. E, The switchboard. F, Turbine-driven exciter. G, Another view in the turbine room. H, The stack is mounted on a separate foundation.

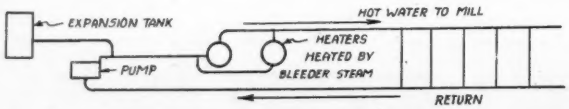


FIG. 7. DIAGRAM OF FORCED-CIRCULATION HOT WATER SYSTEM

rane V-notch meter having a capacity of 300,000 lb. per hr. At this point, also, the lime-soda used for treatment is introduced. The two boiler feed pumps, which are Worthington units, 16 by 10 by 16-in. units of the end-packed, duplex, plunger type, take suction from the meter and deliver the water into the boilers. In addition to this equipment, there is also installed a feed-water stand-by tank which is used when the feed-water heater is off for repairs.

Holly Loop System Used

An interesting feature of this plant is the Holly loop system installed for the return of condensate from the various high-pressure drips to the boilers. This system is not new and most engineers are familiar with the principle upon which the Holly loop operates; however, for those who are not familiar with it, a brief discussion of the general principles may be of interest. The apparatus consists essentially of a closed vessel called the discharge chamber, connected to the boiler by two pipes; one, called the riser is connected through the receiver to the steam space of the boiler and the other called the return, to the water space. With this arrangement the water in the return stands at the same level as that in the boiler, because the pressure in the discharge chamber equals that in the boiler.

If the pressure in the discharge chamber is lowered by some suitable means (in practice, by venting the discharge chamber), water will rise in the return to such a height that the added weight of the water will balance the difference in pressure between the boiler and the chamber, and steam will flow through the riser in an effort to balance the pressure. Any water carried by the steam will be swept along and delivered into the discharge chamber, where it falls to the bottom and enters the boiler through the return as long as the added weight of water is greater than the difference in pressure between the boiler and the chamber. In this way, slugs of water and steam or rather a spray of water and steam rise from the receivers to the discharge chamber, where separation occurs, the water returning to the boiler and the steam condensing, a little of it blowing out of the vent pipe to reduce the pressure.

This system operates without attention and has been found highly satisfactory at this plant.

Features of the Turbine Room

Perhaps the most striking feature of the turbine room is its spaciousness. The designers evidently realized the importance of space and allowed plenty of it between the various units. The room itself is faced with brick painted white with a white tile wainscoting on the walls extending to a height of six feet above the floor. The floor is of concrete and the roof of gypsum. Excellent illumination is provided, during the day by large windows on three sides of the room and at night by 300-w. lamps fitted with enameled steel reflectors, suspended from the roof members. All steam piping is in the basement, the only lines being visible are those leading up through the floor to the turbines. A ten-ton Box crane is provided for handling equipment.

Three turbo-generators are installed, two large units for handling the day load and one small machine for night service.

The two large turbines are Westinghouse units while

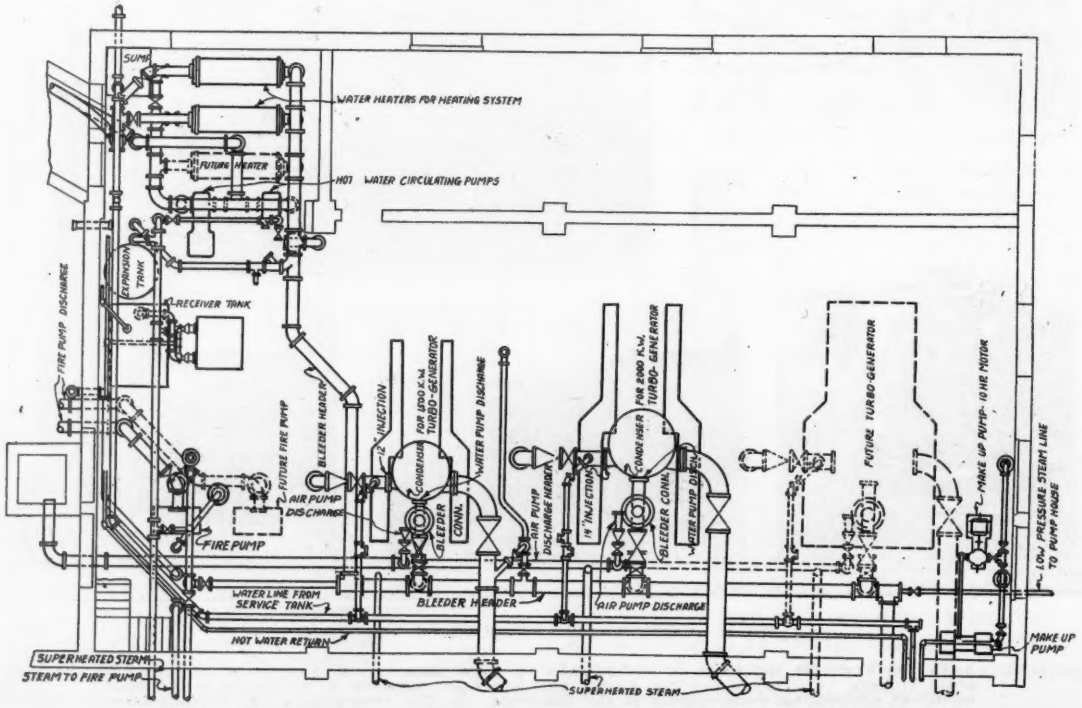


FIG. 8. ARRANGEMENT OF PIPING AND EQUIPMENT IN TURBINE ROOM BASEMENT

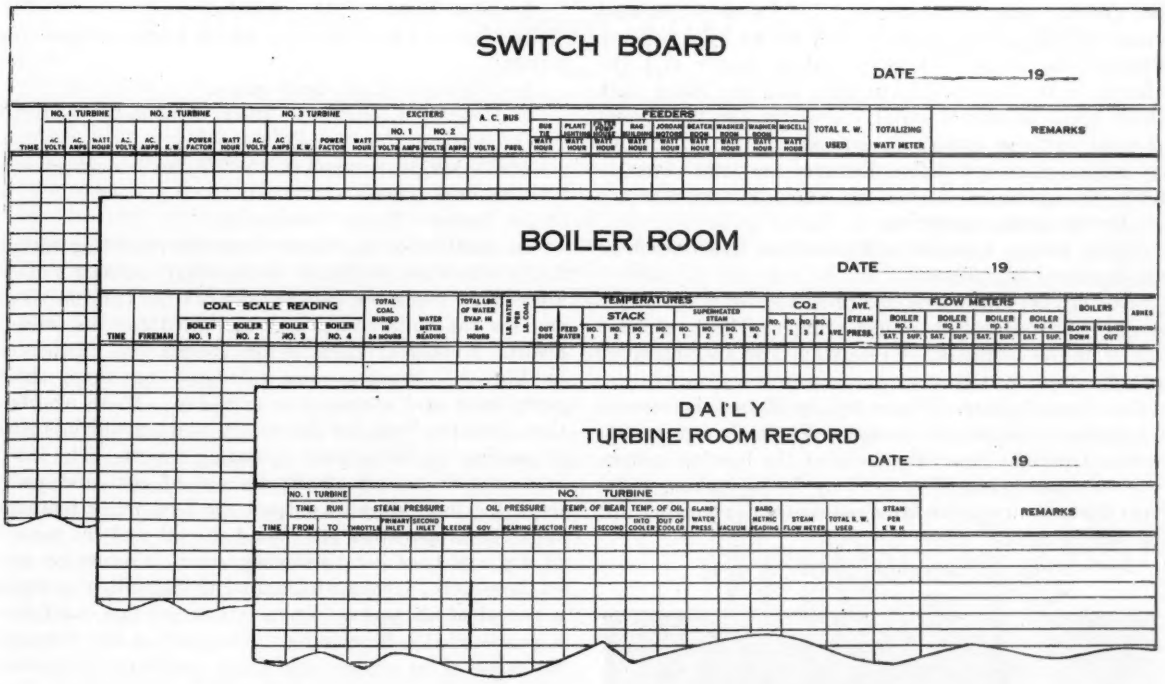


FIG. 9. RECORDS OF OPERATION ARE KEPT BY MEANS OF THESE THREE FORMS

the small one is a General Electric Co. machine. They are described as follows:

1—2500-kv.a. Westinghouse, 480-v., 3-phase, 3600-r.p.m., bleeder type unit, equipped with Westinghouse Le Blanc jet condenser, centrifugal air and condensate pumps, Andale oil cooler and a Worthington 4½ by 3¾ by 4-in. steam-driven auxiliary oil pump.

1—1875-kv.a. Westinghouse, 480-v., 3600-r.p.m., bleeder type unit, equipped with Westinghouse Le Blanc jet condenser, centrifugal air and condensate pumps, Griscom-Russell "multiwhirl" oil coolers and a Worthington auxiliary oil pump.

1—100-kw. General Electric, 480-v., 3600-r.p.m. non-condensing turbo-generator with a direct-connected exciter rated at 4.5 kw., 125 v.

Excitation for the two large units is furnished by either of two separately driven exciter units, one a General Electric Co. set of 50 kw. capacity driven by a G. E. non-condensing turbine and the other a 50-kw. motor-driven Westinghouse machine.

Generator windings are cooled with air drawn from outdoors by fans on the generator rotors.

Steam is bled from the main turbines at from 2½ to 3 lb. pressure, this being used for heating the feed water and for heating purposes in the mill. This bled steam is carried in a common low pressure main into which the steam-driven auxiliaries also exhaust.

Provision has been made for the addition of a third large turbine should future load conditions make that necessary. Openings for the foundation of this future unit have been left in the floor and holes for the steam lines have been provided in the basement walls. The openings in the turbine room floor are now closed with hollow tile.

Condensing water is drawn from the Delaware River through traveling water screens made by the Sanitation Corporation and driven by Crocker Wheeler motors. These screens which are installed in a screen house near the power plant, not only screen the water for the power plant but that for the paper mill as well.

Electrical Features

All current is generated and distributed at 480 v., 3-phase, 60-cycle, control being effected through a 26-panel switchboard of Westinghouse construction fitted with remote controlled generator and feeder switches. The voltage is maintained constant by means of a Westinghouse vibrating type regulator installed on the end panel of the board. The first seven panels from the left of the switchboard constitute the control equipment for the generators and exciters; the remaining panels are feeder panels. A totalizing panel between the generator panels and the feeder panels on which is mounted a recording wattmeter and ammeter, measures the entire electrical output. A swinging bracket at the end of the board on which are mounted the voltmeter, frequency meter and synchroscope makes it possible to see these instruments from any point along the board. All current is sent to the mill by means of conductors installed in underground ducts.

The Turbine Room Basement

Besides the jet condensers and associated pumping equipment, the turbine room basement contains all the various pumps and heating tanks, required, with the exception of the feed pumps and feed water heater. The latter, as already stated, are installed in the boiler room.

A plan showing the arrangement of equipment in the turbine room basement is shown in Fig. 8. The two heaters shown in the upper left-hand corner of the room are used for heating water for the hot-water heating system. The latter is an Almirall & Co. forced circula-

tion system, using two heaters, 2 De Laval centrifugal pumps of 2000 g.p.m. capacity, one driven by a Crocker Wheeler Co. 50-hp., 60-cycle, 3-phase motor and the other by a De Laval steam turbine, and one water tank which keeps an ample supply of water for the system on hand and also acts as an expansion tank. The storage tank is provided with a Reliance low level alarm to notify the operators in case the water level became too low for successful operation.

Other pumps installed in the turbine room basement are described as follows:

2—Duplex, steam-driven units, 7½ by 6 by 10 in. serving as condensation return pumps. These take suction from the condensation receiving tank and discharge into the open feed heater.

2—Duplex pumps, 7½ by 4½ by 10 in., also serving as condensation return pumps. These, however, take suction from the receiving tanks of the heating system.

1—Duplex pump, 7½ by 7 by 10 in., taking water from the well under the filter plant and discharging into the service tank.

1—6 by 5¾ by 6-in. sump pump.

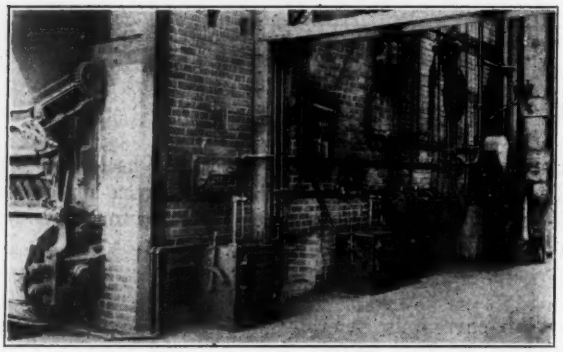


FIG. 10. THE SIDE WALL OF ONE OF THE BOILERS

1—Duplex steam-driven plunger type inside packed pump 20 by 12 by 16 in., 1500 g.p.m., 80 lb. pressure for fire service.

All of these pumps are Worthington units.

An oil storage and separating system is also installed. This consists of a De Laval oil separator driven by a De Laval Emerson motor, and two tanks of about 100 gal. capacity, for clean and used oil respectively. A Viking centrifugal pump driven by a Century repulsion starting, induction motor delivers the oil to the turbine bearings.

Keeping Records of Operation

In operating this plant those responsible leave little or nothing to the imagination. Records are kept of all commodities used and the items tabulated and charted so that they may be correctly interpreted and the knowledge thus gained applied to operation. An excellent assortment of instruments are installed, giving both graphic and visual indications of operating performance. Instruments installed are as follows:

4—Bristol superheat and flue-gas recording thermometers.

1—Bristol feed-water temperature recording thermometer.

1—Bristol pressure recorder.

4—Mono Duplex CO_2 recorders.

4—General Electric Co. steam flow meters (on boilers).

4—Ellison inclined draft gages.

1—General Electric Co. steam flow meter (electric type) on steam line to mill.

2—Taylor Instrument Co.'s "Tycos" mercury column vacuum gages.

1—Taylor "Tycos" barometer.

In addition to the charts from the recording instruments which are filed daily in the chief engineer's office, three main records are kept, one for the turbine room, one for the boiler room and the third for the switchboard. Copies of these record forms are reproduced in Fig.. 9. Readings are tabulated on these sheets every hour and averaged once a day. These averages then form the basis for the weekly average which is used in making up the annual operating report. The latter is a graphic record of the amount of coal and water used, the total kilowatt output, the feed water temperature, the evaporation per pound of coal and the pounds of dry coal used per horsepower-hour. Curves for each of these items are drawn parallel to each other covering a period of 52 weeks. From this record one can tell at a glance what is happening in the plant at any time and the cause of an unusual operating condition determined. This record is similar to that used in the Passaic Plant and described in the Sept. 15, 1924 issue except that the items, total kilowatt output, and feed water temperature have been added.

Besides the daily and weekly operating record, the chief engineer keeps a daily record of the coal used under each boiler and the total for the week; a daily and weekly record of the amount of water evaporated, and a general record of operation. These three records are kept in books which are kept on file in the chief engineer's office.

It must be evident that with these records, a close check can be maintained on all operating conditions and that undesirable conditions may be quickly detected and rectified.

A spirit of co-operation prevails among the various operators and all seem to be interested in the efficient operation of the plant.

In concluding this article we wish to acknowledge our indebtedness to the Paterson Parchment Paper Co., particularly to R. T. Anderson, assistant general manager and to D. Minkema, chief engineer of the Edgely plant, for privileges extended in collecting material for this article. Credit is also extended to Abbott, Merkt & Co., Inc., of New York for supplying us with blue prints for illustrating purposes.

Average daily production of electricity by utility plants is given as 195,850,000 kw-hr. for June, 1926, an increase of 4.5 per cent over May. For the first 6 mo. of 1926, production was 35,330,000,000 kw-hr., a 12 per cent increase over the like period for 1925, of the total 5,875,427,000 kw-hr. produced in June, 2,231,626,000 were from hydro-electric plants and 3,643,801,000 from fuel-burning plants. Fuels used were, coal 3,171,889 short tons, oil 620,628 bbl., gas 4,258,909,000 cu. ft.

Fuel oil heaters should be thoroughly cleaned out once each year.

Principles of Steam Turbine Governors

DETAILS OF CONSTRUCTION AND METHOD OF OPERATION OF VARIOUS MAKES OF GOVERNORS USED ON STEAM TURBINES TODAY

AS THE NAME implies, the purpose of a governor on a steam turbine or upon any type of engine is to govern the speed of the machine. The speed of a turbine not equipped with a governor and supplied with steam at constant pressure would fluctuate widely with changes in the load. At light loads it would run extremely fast and at low loads it would run slow; in fact, under excessive loads the machine might even stop.

Most applications of the steam turbine, however, require a nearly constant speed regardless of the load. There are exceptions but they are few. In marine work, where the turbine is attached directly to the propeller, where there is no danger of the load being removed, and where the resistance, which the propeller offers to the rotation of the turbine, increases with the speed, a turbine without a governor will function satisfactorily. In most stationary applications, where there is danger of the load being suddenly removed (in which case the turbine would probably speed up to destruction) a governor is a necessity.

In general, a steam turbine governor consists of two main parts, first, a valve or a group of valves by which the steam input to the turbine may be varied and second, a device which will operate this valve arrangement in accordance with the speed of the turbine. The exact manner in which these two functions are accomplished varies widely with different types and makes of turbines. On small turbines, the speed sensitive device controls the steam admission directly, that is, through a system of gears, levers or cams. In the case of large machines, however, the force necessary to actuate the steam admission device is too great to permit of direct operation and it is accomplished by means of steam or oil pressure through the agency of a relay. These two methods are known as the direct and indirect, or relay, methods respectively.

With only few exceptions, practically all governors are controlled in some way by centrifugal force. An exception to this case is the governor used on Ridgway turbines which employs air pressure supplied by an impeller driven direct from the main shaft. In another case a positive displacement pump varies the amount of oil to the operating cylinder in accordance with the speed. Most other makes, however, use a modification of the flyball or centrifugal governor, connected direct or geared to the turbine shaft. For turbines driving alternating-current generators, an external spring is often used whose tension can be adjusted by a small electric motor, controlled at the switchboard to aid in synchronizing.

Steam admission to the turbines is accomplished by one of four methods or a combination of these: These are, (1) throttling of the steam as it enters the steam chest; (2) varying the area for admitting the steam to the turbine, usually by varying the number of nozzles in action; (3) admitting the steam intermittently in puffs at varying intervals (often called the blast method); and (4) by means of hand-operated bypass valves.

Among these four methods the first is perhaps the most widely used, particularly on small turbines. It is simple, reliable, and gives satisfactory service. While the throttling action of the control valves of governors of this type decreases the efficiency at low loads somewhat, in the case of small machines this is not so important. It is because of this lowered efficiency at low loads, that other types of governors are used on large turbines.

In order to convey a clear idea of the construction and action of governors used on modern steam turbines, a number of the principal makes will be described. In many cases one company will make several different types of governors and, while no attempt will be made to describe all of these various types, we shall select what in our opinion are the most representative.

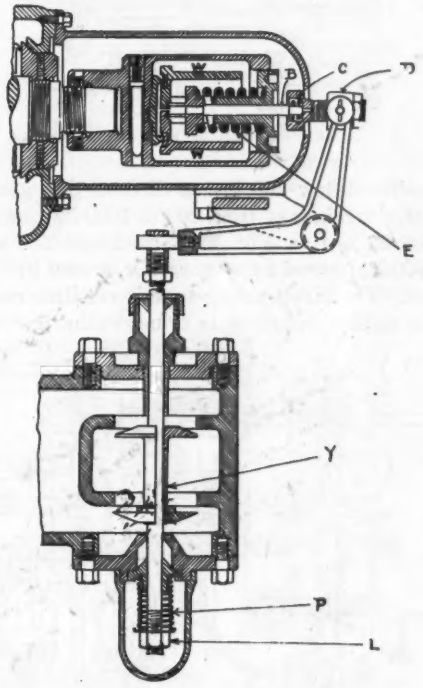


FIG. 1. MAIN REGULATING GOVERNOR AND VALVE OF STURTEVANT TURBINE

THE STURTEVANT GOVERNOR

In Fig. 1 is shown a diagram of the main regulating governor and valve used on Sturtevant turbines. It is, as will be noted, of the centrifugally-actuated, direct-acting, throttling type. As the speed of the turbine increases, the centrifugal weight arms, W, fly out, forcing the governor spindle B against the ball-bearing socket C, located in the head of the bell crank lever D. This motion is, in turn, imparted to the valve Y, which lifts up and closes the steam ports. When the speed decreases, the weight arms W are drawn in by the centripetal force of the main governor spring E and the external spring P

pulls down on the end of the bell crank D, causing the ball-bearing socket C to follow the inward movement of the governor spindle B, thereby lowering and opening the valve Y. In other words, the governor closes the valve and the external spring opens it. The tension of this spring P is governed by the adjusting nut L.

Governors on Kerr Turbines

Governors used on Kerr turbines are of three types, depending upon the size of the machine. On small units

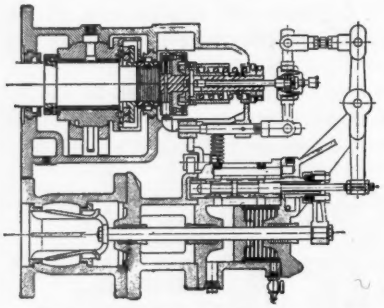


FIG. 2. OIL RELAY GOVERNOR FOR SMALL KERR TURBINE

of capacities below 200 kw., a direct-acting governor is used. For turbines of from 200 to 1000 kw., an oil pilot governor, shown in Fig. 2, is used and for machines over 1000 kw. an oil relay governor, shown in Fig. 3, is supplied. The direct-acting type is not illustrated here, but it is similar in principle to most other governors of

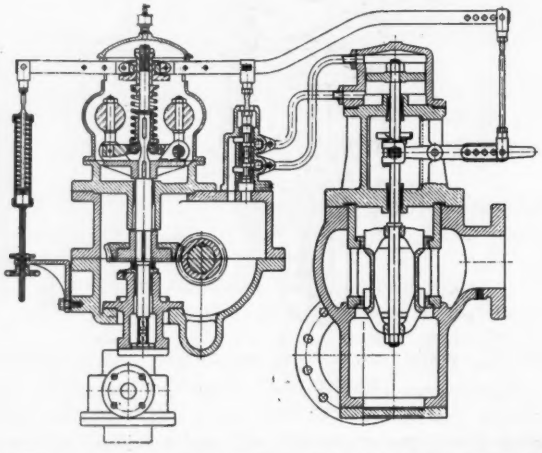


FIG. 3. OIL RELAY GOVERNOR USED ON LARGE KERR TURBINES

this type. The details of construction, of course, are individual with the manufacturer.

The oil relay type, shown in Fig. 2, is similar to the direct-acting type, except that the governor valve is controlled by means of an oil pilot or relay which admits oil under pressure to one or the other side of the main operating piston which opens and closes a double-seated, balanced governor valve controlling admission of steam to the turbine, hence its speed. The governor weights are mounted directly on the turbine shaft, a non-rotating spindle being used through which oil is fed to the moving governor parts.

The oil relay type used on machines over 1000 kw., shown in Fig. 3, is of different design. It is of the spring-loaded centrifugal type with spherical weights and is gear driven from the turbine shaft. The governor motion is transmitted through linkage to the pilot valve of an oil relay cylinder, which admits oil under pressure to one or the other side of the main operating piston.

Moore Turbine Governors

Another governor of the direct-acting type is the one shown in Fig. 4, which is that used on Moore steam turbines of the smaller sizes. It consists of annular weights pivoted on hardened steel knife edges, held against flying apart by a strong steel spring. Motion of the governor spindle is transmitted through a lever and valve stem to a balanced valve which controls the amount of steam passing to the turbine.

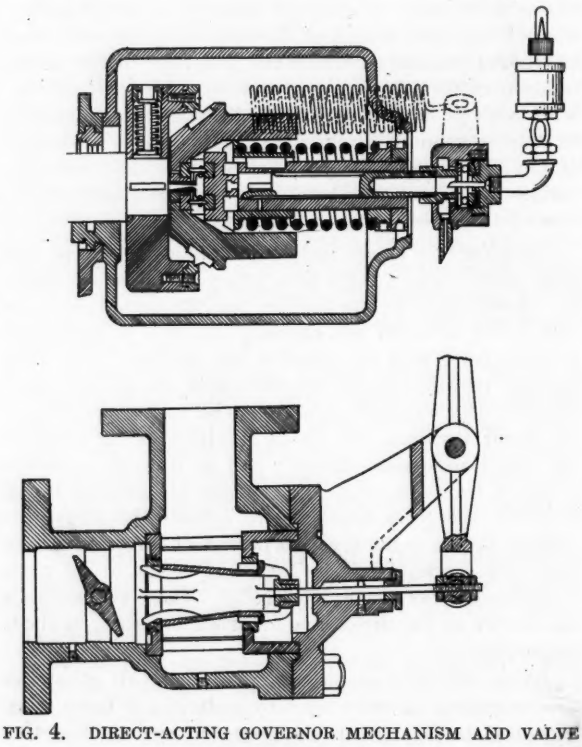


FIG. 4. DIRECT-ACTING GOVERNOR MECHANISM AND VALVE OF MOORE TURBINE

For use with their large turbines, the Moore Steam Turbine Corporation furnishes an oil relay governor. This governor, shown in Fig. 5, is driven from the main turbine shaft through a worm gear. An increase in speed causes the governor weights to move outward. This moves the governor lever upward, moving the relay valve which admits oil below the piston P. This causes the governor valve to close. Movement of this valve, however, moves the starting lever, which brings the governor valve back into its neutral position. This stops the flow of oil and prevents over-travel of the steam valve. The governor steam valve is provided with a spring S at the lower end of the valve stem, the purpose of which is to close the valve automatically and shut down the turbine in case the oil pressure fails. An over speed governor is also provided, as shown, above the worm gear. In this a weight, held in place by compression of a spring until a predetermined speed is

reached, trips a latch allowing the trip valve to be forced upward by spring B. This admits full oil pressure under piston P and exhausts oil from above the piston, closing the governor steam valve. If the speed decreases instead of increases, the opposite takes place. For every movement of the governor, there is a corresponding governor valve movement. In practice the valve movement follows the governor motion so closely that no movement of the relay is noticeable.

Speed may be adjusted while the turbine is running by means of the synchronizer. This may be done by hand, as shown, or by a motor controlled from the switchboard.

Terry Governors

Terry steam turbine governors are also made in two types, one the direct acting for small machines and the other an oil relay type, where exceptionally large valves are to be controlled. The former, shown in Fig. 6, is

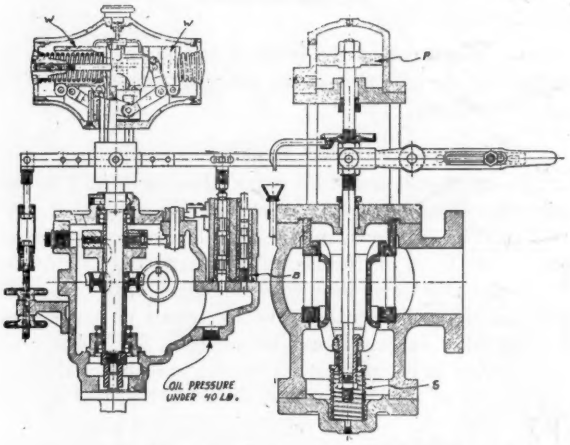


FIG. 5. MOORE OIL RELAY GOVERNOR

of the flyball type, the centrifugal force of the weights C being opposed by the spring F. As the speed rises, the weights move out from the shaft, pressing the governor slide H to the left, closing the governor valve through the lever P. If the speed drops slightly, the weights move inward to a corresponding extent, allowing the governor valve to open enough to carry the load.

If only a few per cent speed change is required, it can usually be secured by means of the governor adjusting nut. If a greater variation of speed is required than can be secured by this adjusting nut, new governor weights or springs can be supplied.

The type of valve used in connection with this governor is of the double-seated, balanced type and is constructed so that only a small force is required to operate it.

The oil relay governor of the Terry turbine differs from the direct-acting type in that the governor slide H (Fig. 6) instead of operating the governor valve, moves only the pilot valve shown in Fig. 7. Movement of this valve admits oil pressure to one side or the other of the valve piston, causing the steam valve to open or close. Movement of the valve stem also moves the floating lever, returning the pilot valve to its central position and stops further movement of the steam valve until there is another impulse from the governor.

With this type of governor, speed variations of one or two per cent can be obtained by adjusting the twin buckle on the connecting rod. Lengthening the rod lowers the speed and is safe to do. Shortening the rod raises the speed, but great care must be taken that the

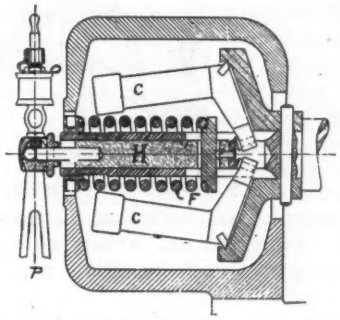


FIG. 6. GOVERNOR MECHANISM OF THE TERRY TURBINE

governor weights do not strike the governor housing due to over adjustment.

De Laval Turbine Governors

Governors supplied with De Laval steam turbines differ according to the type and size of turbine. The direct-acting type used on small machines is similar in principle to those already described, but is made in two designs, one having the governor mounted horizontally

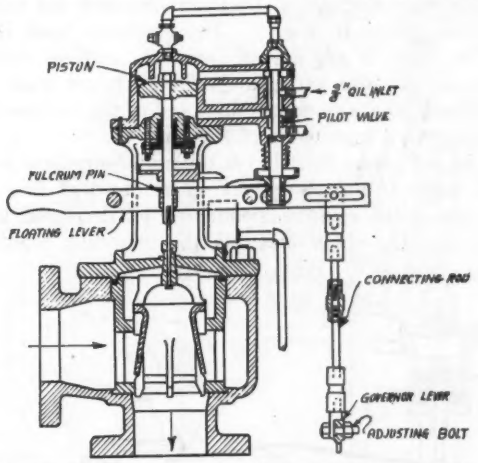


FIG. 7. OIL RELAY AND VALVE OF GOVERNOR USED ON LARGE TERRY TURBINES

on the turbine shaft and the other having it mounted vertically, gear driven from the shaft. The latter is used on velocity stage turbines with speeds above 3600 r.p.m., where the vertical, gear-driven governor is to be preferred for purely mechanical reasons. These governors, the horizontal and vertical, are used mostly on small turbines, driving pumps and blowers.

Figure 8 shows a conventional-type governor for a multi-stage turbine to drive a centrifugal pump, where extremely close speed regulation is not necessary. A pump load is usually a steady load with relatively small load changes. The operation of this governor is as follows:

"A" is the turbine shaft driving an oil pump of the positive displacement type B by means of a worm and

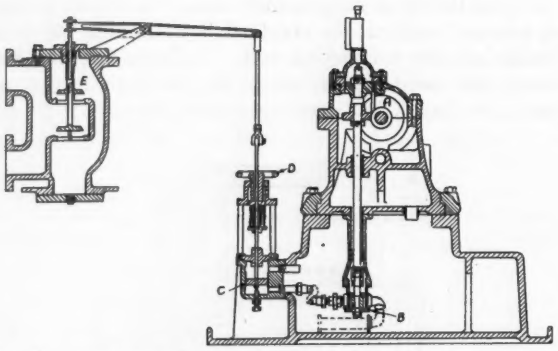


FIG. 8. IN THIS DE LAVAL GOVERNOR, A POSITIVE DISPLACEMENT PUMP VARIES THE OIL SUPPLY TO AN OPERATING CYLINDER IN ACCORDANCE WITH THE SPEED

gear. This oil pump delivers oil to an oil cylinder with piston C. The piston is provided with a fixed orifice, so that the amount of oil passing through the cylinder is fixed for each different pressure generated by the oil pump. Any change in the speed of the oil pump, which is of the positive displacement type, results in a change in pressure and a corresponding movement of the piston. As the pressure of the oil on the under side is compensated for by an adjustable spring "D," any motion of the piston is transmitted directly to the governor valve E, as indicated.

For generator drive, De Laval employs the type of governor shown in Fig. 9. The governor head D and the oil pump B are driven from the turbine shaft by means of a worm and gear. The governor head is of the flyball type, any change in speed of the turbine shaft resulting in a movement of the lever H.

The oil pump B delivers oil under pressure at the relay valve C and movement up or down of this valve determines the relative amount of oil delivered to the oil piston G, which operates the governor regulating

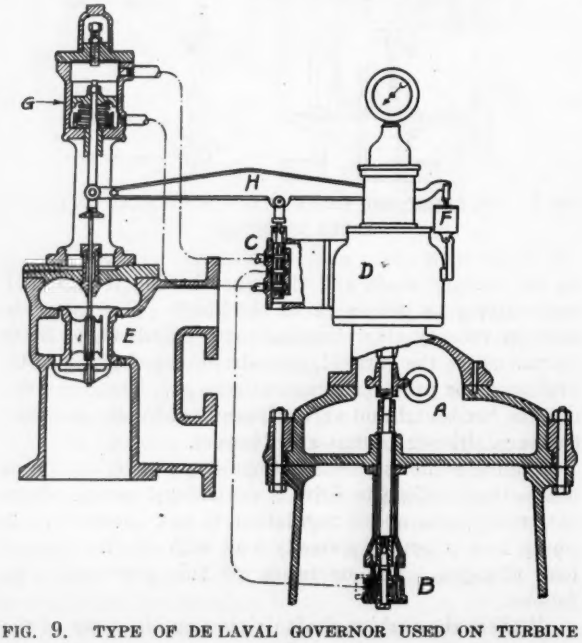


FIG. 9. TYPE OF DE LAVAL GOVERNOR USED ON TURBINE DRIVES

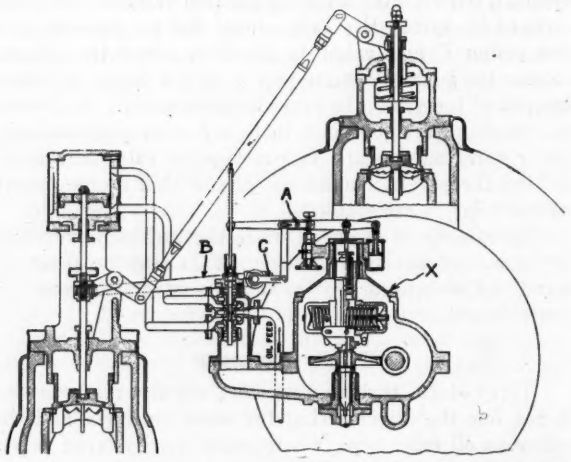


FIG. 10. ALLIS-CHALMERS OIL RELAY THROTTLING AND BYPASS GOVERNOR

valve. Movement of the lever H is compensated for by attaching one end of it to the governor valve stem. F is an oil dashpot.

ALLIS-CHALMERS TURBINE GOVERNORS

The Allis-Chalmers oil relay throttling and bypass governor used on machines ranging in size from 5000 to 15,000 kw. is shown in Fig. 10. The governor proper, shown at X, is of the centrifugal spring type, driven by means of a worm gear from the main shaft. It operates a balanced throttle valve by means of an oil-controlled relay valve. It can be adjusted for speed while the turbine is in operation, thereby facilitating the synchronizing of alternators and dividing the load as may be desired.

The arrangement shown in Fig. 10 is not strictly correct in all its details, the design being slightly modified in certain places to show more clearly the important features. Its operation is as follows:

Any change in speed causes an immediate change in the position of the governor weights, which movement is promptly transmitted through the vertical rod to the horizontal floating lever. The horizontal lever is pivoted at A, so that any movement in the governor is transmitted to the oil relay plunger which, in turn, opens the ports in the oil relay valve, admitting or releasing the oil above or below the piston in the oil relay cylinder.

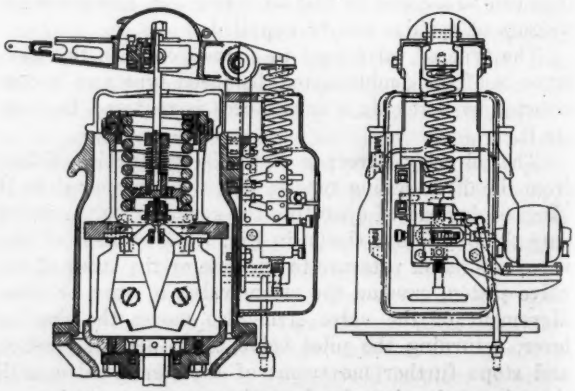


FIG. 11. OPERATING MECHANISM OF G. E. TURBINE

as the cause may be. Any movement of the inlet valve is at once transmitted back to the relay valve through the compensating levers B and C, closing off the ports in the relay valve when the inlet valve has taken up the desired new location.

Synchronizing is achieved by means of a hand wheel which raises or lowers the fulcrum A, thus changing the location of the relay valve with reference to the governor. Ordinarily, the speed of the unit can be changed by means of the synchronizing device 5 per cent above or below the normal speed limit of the unit.

General Electric Co. Governors

In Fig. 11 is shown a diagram of the General Electric (Form E) operating governor. This governor is of the centrifugal type driven by the turbine shaft through a worm gear, which reduces the speed of the governor to about 25 per cent of that of the turbine. The motion of the weights is transmitted by a hydraulic mechanism to the controlling valve, or valves, which regulate the flow of steam to the turbine. When the turbine-generator set is operating alone, the governor holds the speed constant under changing load conditions but when the generator set is connected in parallel with an electrical system, the speed of the set is determined by the frequency of the system, thus the governor controls the load on the generator.

This governor consists essentially of two weights which are swung outward by centrifugal force against the pull of a spring lowering the revolving spindle which pulls down the horizontal beam through a small angle. This motion is transmitted to the pilot valve of a hydraulic cylinder, which operates the controlling valves on the steam supply until the desired speed change has been secured.

In synchronizing, the action is as follows: The compression of the synchronizing spring opposes the tension of the main spring of the governor and has sufficient force and adjustability to provide for a broad range of speed and load when the turbine is operating under the control of the governor. The change in compression and, therefore, in the force of the synchronizing spring, is made by the movement of the synchronizing nut on the lead screw. The motor provided to turn this screw is remotely controlled, usually from the operating switchboard; ordinarily this method of moving the synchronizing nut is used.

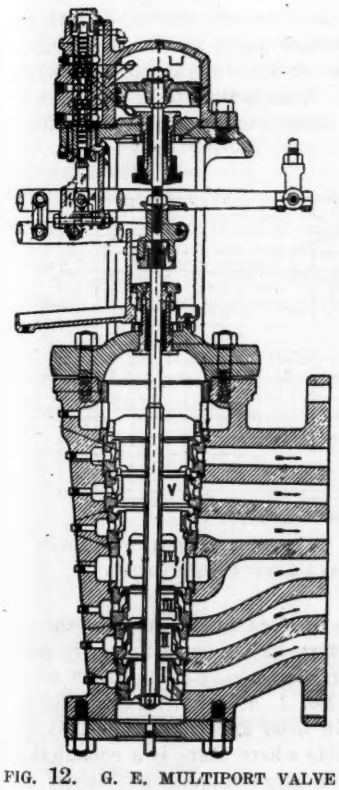


FIG. 12. G. E. MULTIPORT VALVE MECHANISM

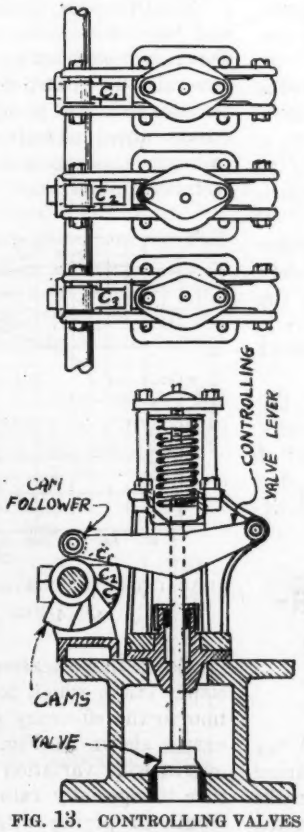


FIG. 13. CONTROLLING VALVES USED ON SOME G. E. TURBINES

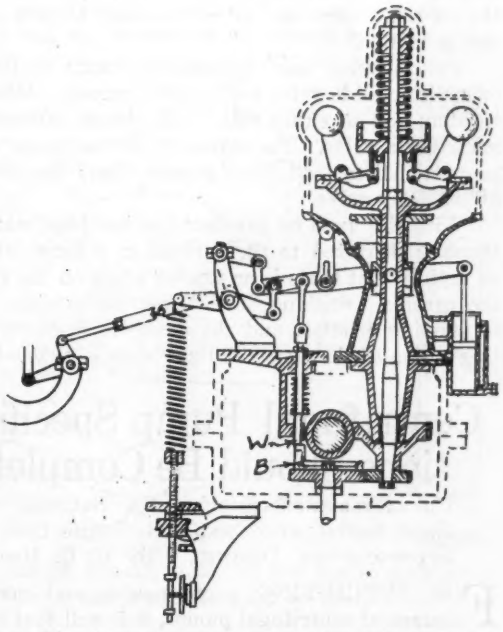


FIG. 14. INTERMITTENT TYPE GOVERNOR USED ON WESTINGHOUSE TURBINES

Valve arrangements and mechanism used with General Electric governors vary with the type and size of turbines on which they are used. An arrangement using a multi-ported valve is shown in Fig. 12. It consists of an operating cylinder, together with pilot valve, and a controlling chamber. The arrangement is such that as the valve stem rises, the valves, I, II, III, etc., open successively. Only one valve opens at a time. The rest are either all closed or open. With this type of valve there is little throttling action and the governing is accomplished chiefly by varying the number of nozzles to which steam is admitted.

Another type of governor valve mechanism is shown

in Fig. 13, which shows in section one of a number of valves arranged side by side along the top of the turbine casing. The shaft S, moved by the oil relay through a rack and pinion, has keyed to it at different angles the cams C_1, C_2, etc. When the operating piston moves these cams strike the cam following rollers R, successively causing the various valves to lift, each in its proper order. These valves admit steam to the various nozzles on the turbine.

Westinghouse Governors

The governor shown in Fig. 14, used on certain turbines of the Westinghouse Electric & Mfg. Co., is typical of those governors employing the third principle of steam admission as listed at the beginning of this article, i. e., admitting the steam intermittently in puffs at varying intervals. The puffs occur at regular intervals so frequently that there is no uneven effect on the speed of the turbine.

In this governor, which is driven through a worm gear from the turbine shaft, a cam B is driven by a gear from the governor spindle. This cam imparts a rocking motion to the system of levers connecting to the oil relay valve and gives the relay valve a reciprocating motion.

This oil relay valve operates somewhat on the order of a piston slide valve for a steam engine. Alternately it admits oil to either side of the piston operating the main steam valve. The movement of the steam valve is proportional to (but much greater than) the movement of the relay valve.

With this type of governor, as has been stated, the steam is delivered to the turbine in a series of puffs, so rapidly that there is no uneven effect on the speed of the turbine. Sticking of the governor mechanism due to starting friction, and the energy loss due to throttling action of the steam at light loads is avoided.

Centrifugal Pump Specifications Should Be Complete

Characteristics Should Be Studied for Each Installation and All Terms Used in Specifications Defined. By C. C. Brown

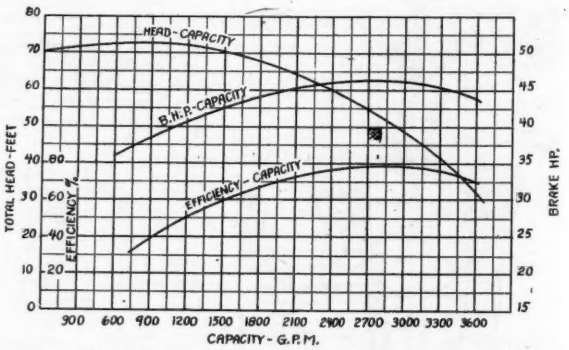
FOR SPECIFYING performances and comparing designs of centrifugal pumps, it is well that even the commonest terms, such as power and efficiency be defined. The water horsepower is defined as the foot-pounds of work per minute divided by 33,000. The foot pounds per minute are equal to the weight of water handled per minute multiplied by the head in feet.

Correct determination of the head is sometimes the cause of confusion. The head is measured by reading the suction vacuum and discharge pressure gages and adding these two together in terms of feet of water correcting for the distance between the levels of the gages and for the velocity head in the discharge pipe.

Efficiency of the centrifugal pump is, to a great extent, dependent upon a favorable combination of head, capacity and speed. In order to generate a given head, the actual linear velocity of the periphery of any impeller of the usual type must, within certain narrow limits, be the same. The speed is therefore determined by the impeller diameter, but increase in impeller diameter means increased area of frictional surface, causing a rapid increase in the amount of power lost. Thus the smaller the impeller diameter and the higher the rotative speed the higher the efficiency, a condition which is also true of the driving member. The limiting dimension to which the diameter can be reduced is that of the inlet eye, through which the water must enter the impeller at a moderate velocity.

It is often undesirable to run at arbitrary speeds and whenever possible the choice of a proper speed should be left with the pump builder, in order that the best possible efficiencies for a given condition may be obtained. Many times when a motor or turbine which happens to be on hand, is not of the proper speed, the saving over the price of new equipment is soon offset by the increased power consumption due to unavoidable lowering of the efficiency.

Simultaneous variations in head, capacity, efficiency and brake-horsepower input for a given pump are best shown by constructing characteristic curves. These are generally taken at a constant pump speed. The characteristics of the pumps shown in the accompanying curves were determined from actual tests made under ordinary conditions of operation in the case of newly installed pumps.



CHARACTERISTIC CURVES OF A CENTRIFUGAL PUMP CAN BE OBTAINED ACCURATELY BY TESTS

Particular attention is called to the shape of the efficiency curve which is very flat, thus insuring, in addition to the efficiency of 80 per cent in the case of the curves shown in Fig. No. 1, a high average efficiency over a wide variation in head and capacity. This feature is especially valuable where there is a considerable length of piping with a large number of elbows and other fittings so that the estimated frictional head forms a large percentage of the total pumping head. In this case the friction head is added to the sum of the suction and discharge heads with standard allowances for elbows and other fittings. As all methods of estimating friction losses are necessarily approximate and depend to a great extent upon such factors as smoothness of pipe, length of time that it has been in service, type of service, and radius of bends, it is customary to estimate the maximum possible loss and then allow a slight additional amount for safety. This sometimes results in the specifications calling for a head several feet higher than actually required. With a pump having a flat efficiency curve or characteristic, this is not a serious disadvantage, as the effect of a variation of ten or fifteen per cent is negligible as far as the efficiency of operation is concerned.

Brake horsepower curves should also be studied. This

reaches its maximum value at the rated head and capacity and any variation in these is accompanied by a falling off of the power required. This is of prime importance in the case of a motor driven pump, when a power curve which rises abnormally after the capacity exceeds the rated amount, as is the case with many pumps, would seriously overload the driving unit or necessitate the use of a motor of larger capacity than is really required. Centrifugal pumps which operate continuously under widely varying loads and heads as in drydock service should receive particular attention in connection with this point.

Performance of a centrifugal pump cannot be accurately prophesied upon purely theoretical calulations alone, but must also be based upon the analysis of numerous actual tests covering a wide variety of conditions. It is therefore well when choosing pumping equipment to determine if possible, just what the equipment will do under actual test. In almost every case the present day manufacturers of centrifugal pumping equipment have equipped their plants with suitable laboratories in which all pumps are thoroughly tested and characteristic curves secured before the pumps are delivered.

Flow Measurements with the Flat Plate Orifice

SIMPLIFIED FORMULAS AND COEFFICIENTS FACILITATE USE OF FLOW METER FOR TEMPORARY, OR PORTABLE, USE IN AIR, STEAM AND WATER MEASUREMENT

FLOW METERS of the Venturi tube, flow nozzle and flat plate orifice type, with the stamp of approval after successful application to every conceivable service, are now classed as essentials in a modern power plant. Present day fluid measurements deal largely with air, steam and water flowing through pipes under pressure and commercial meters are widely used. Use of the flat plate orifice, however, as a temporary, or portable meter, has never received the attention that its simplicity and ease of application warrant, due, no doubt, to the technical nature of the available literature and the difficulty of applying the experimental data to actual conditions of service.

Fundamentally, the principle of operation of the three meters is the same, the pressure drop which accompanies an increase of velocity at constant flow. In

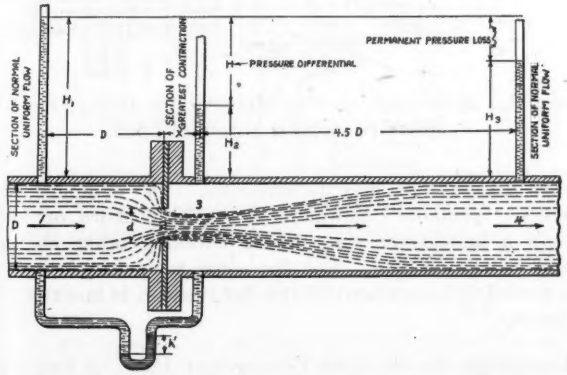


FIG. 1. CROSS SECTION OF A TYPICAL FLAT PLATE ORIFICE INSTALLATION, SHOWS ACTION OF THE FLUID

a pipe of varying cross-section, the flow past any section is equal to the product of area and velocity. The total energy remains constant and is equal to the sum of the pressure energy and velocity energy at any section. If d in Fig. 1 is equal to 0.5D, the velocity at Sec. 2 must be four times that of Sec. 1. This increase of velocity takes place at the expense of pressure and a manometer connected across Secs. 1 and 2 would show a pressure difference, the lower pressure existing at Sec. 2. Due to the action of the jet, it continues to contract for some time after passing the orifice, the section of smallest area being called the vena contracta. As this represents the highest velocity or lowest pressure, a manometer connected across this, Sec. 3, and the upstream side Sec. 1 shows the greatest pressure deflection for any given flow.

MONEL METAL MAKES BEST ORIFICE FOR PERMANENT USE

The complete meter consists of the metering element, or orifice and the manometer, or recording device. For

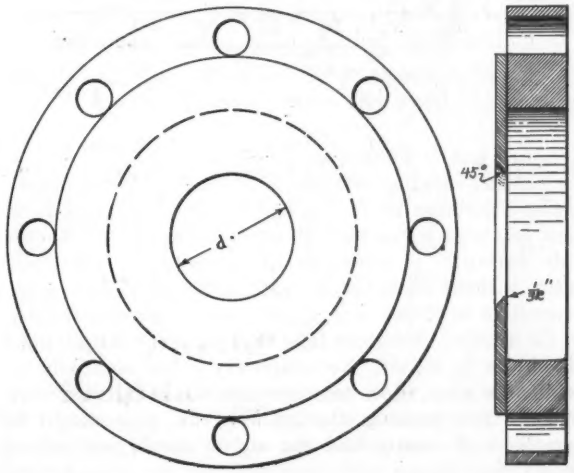


FIG. 2. ORIFICE PLATES MADE TO FIT INSIDE THE BOLT CIRCLE ARE MUCH HANDIER TO INSTALL

permanent installations, commercial flow meter companies use monel metal exclusively but, for temporary use with water and air, medium weight galvanized iron will give good service. This can be machined best by clamping between wooden blocks. High temperatures, however, soften and bend such plates out of shape, so that it is best to use ¼-in. boiler plate for steam measurements. These are machined to size with the downstream side beveled at an angle of 45 deg. as in Fig. 2. Although considerably more expensive, such orifices are easier to machine accurately, easier to work with and more satisfactory than the lighter sheet iron.

For large ratios of d/D, where the orifice must be centered accurately, it may be made the same diameter as the flange, although the ring type, made to fit inside the bolt circle, is much more convenient to use. The outside diameter of the orifice can be made equal to that of the bolt circle minus the diameter of the holes. This

leaves ¼ in. leeway in fitting bolts, as the bolt holes are ordinarily drilled ⅛ in. larger than the bolts. Where flanges and bolts can be freely moved, the orifice can be made ⅛ in. larger in diameter, although trouble may be encountered unless the flanges have been carefully drilled.

Location of Pressure Taps Affects Readings

Two pressure taps are necessary. The high-pressure or upstream tap at Sec. 1 is always located one pipe diameter above the orifice; the downstream or low-

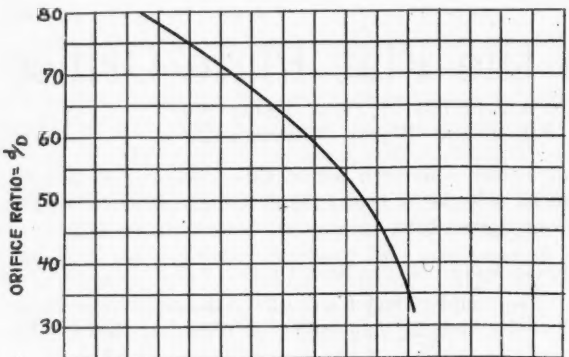


FIG. 3. EXACT LOCATION OF THE VENA CONTRACTA VARIES WITH THE ORIFICE RATIO USED

pressure one is located at the vena contracta, Sec. 3, its location varying with the orifice ratio. For ordinary ratios a distance of ½D is satisfactory, the exact location being given as the distance in Fig. 3. Considerable variation is allowable in the location for lower ratios without affecting the reading but, at higher ratios, around 75 to 85 per cent, slight variations are noticeable in the results. Pressure taps on permanent installations should be ⅜ in. but, for temporary work, especially on small pipe sizes, ¼-in. taps are easier to install and work with. After tapping, the inside of the pipe should be smoothed off square and the nipple should not extend inside.

Taps located in the side of the pipe, as in Fig. 4, are best for general service, although conditions ofttimes make it necessary to locate them elsewhere. If located in the top of a water pipe, air will collect in the pressure pipes, and, if located in the bottom, dirt will cause trouble. Similarly, water collecting in the bottom of an air line will do the same thing if the taps are taken from the bottom of the line. Air meters should be set above the instrument with all lines draining back to the pipes, while water and steam meters are best placed below. This is not absolutely necessary but offers the easiest installation, more care being required to obtain true readings, if other locations are selected. For instance, a water meter placed above the orifice may become air bound, if considerable air is entrained in the water. To eliminate this, reservoirs with gage glasses can be located close by the instrument to be blown down when air collects.

Steam meters must always be installed with reservoirs and valves as in Figure 4. In these meters, pressure is transmitted through water, the reservoir serving as a condenser and as insurance against unequal water legs, when change of flow takes place. When installed on vertical lines, the reservoirs must be in the same vertical plane, as in Figure 5. The drop leg to the lower pressure tap should be well drained back to the steam line.

Ratios of d/D of from 30 to 80 per cent can be used, although the former causes an excessive permanent pressure loss and the latter requires extreme care in centering the orifice. If possible, it is best to stay within the range of from 45 to 65 per cent. With all meters of this type there is a permanent pressure loss across the orifice. Starting at Sec. 1, Fig. 1, the normal pressure begins to increase about 0.75D above the orifice, drops suddenly across the orifice, reaches a minimum at Sec. 3 and gradually regains pressure to Sec. 4 about 4.5D downstream. In many cases this pressure loss is an important item in the cost of metering and is indicated on Fig. 1.

With air and water under comparatively small pressures, an ordinary manometer, made of rubber tubing and glass with a suitable scale, is satisfactory but, for higher pressures and steam, the cheapest and only satisfactory method is to use an ordinary flow meter body. If considerable work is done, the various parts necessary for obtaining full scale deflection with different pressure differentials may be obtained. The ordinary so-called "portable" flowmeter is nothing more or less than a monometer suitable for checking other meters and indicating flow. For the usual temporary service, a recording instrument of standard design is more satisfactory.

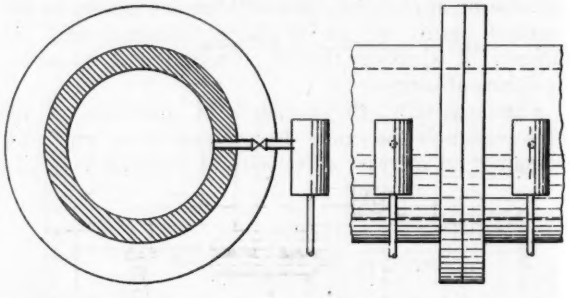


FIG. 4. RESERVOIRS SHOULD ALWAYS BE USED AT THE ORIFICE FOR STEAM MEASUREMENTS

Inches of Water Most Convenient Unit to Use for Differential Heads

Ordinarily, both in manometers and commercial instruments, the pressure differential is measured by a mercury column, but commercial instruments are calibrated in inches of water and this will be found a more convenient unit to use in actual service. With manometers reading in inches of mercury, the actual deflection must be multiplied by the specific gravity before substituting the value of h in the equation. When metering air, the mercury deflection in inches must be multiplied by 13.6 to give the equivalent head in inches of water but, for water and steam, where the mercury is under water and balanced by a water leg, the mercury deflection in inches should be multiplied by 12.6 to give the water equivalent.

Flow through the orifice can be calculated from the

following formula, which represents the fundamental equation, simplified for various services.

$$G = 0.569\ C\ D^2\sqrt{h} \quad (1)$$

$$W = 359\ C\ D^2\sqrt{h/v} \quad (2)$$

$$F = 129\ C\ D^2\sqrt{hP/T} \quad (3)$$

Where

G = g.p.m. of water (50 — 110 deg. F.)
W = lb. of steam per hr.
F = cu. ft. free air per min. (14.7 lb., 60 deg. F.)
V = spec. vol. of steam from tables
P = lb. per sq. in. abs.
T = F. deg. abs.
C = coef. from Fig. 6.
D = internal pipe diameter in inches.
h = differential head in in. of water.

Practically, C is the same for water, air and steam, so that values from Fig. 6 can be used for all three. In addition to the variation of C with the orifice ratio, there is a slight change with pipe diameter and the curve represents coefficients for a 6-in. pipe. These values will give results well within the accuracy of usual temporary measurements for pipe from 3 to 12 in. in diameter even though they vary somewhat from the true value. From practically zero at a ratio of 40 per cent the error increases to about 2 per cent at an orifice ratio of 80 per cent. With usual orifice ratios, the error is so small that the complication of separate curves

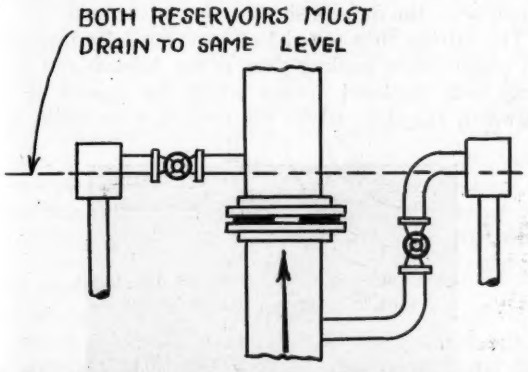


FIG. 5. EVEN ON VERTICAL AND INCLINED PIPES, RESERVOIRS SHOULD BE KEPT IN THE SAME VERTICAL PLANE

for each pipe size is not justified except for extreme accuracy.

As an example, an orifice 3 in. in diameter is to be installed in a pipe line with a measured internal diameter of 6 in. Compressed air at 100 lb. gage is to be measured and the installation is at sea level. The upstream pressure tap should be located 6 in. and, from Fig. 3, the downstream tap 0.44D or about 2⅝ in. from the center of the flange. From Fig. 6, C will be 0.158 with D^2 and P 36 and 114.7 respectively. From measurements the temperature has been found to average about 115 deg F. or 575 deg. abs. and the meter, when set up, shows a mercury deflection of 1.2 in., which is equal to $1.2 \times 13.6 = 16.3$ in. of water. Substituting these values in Eq. 3 gives a flow of 1325 cu. ft. of free air per minute. Applied to conditions other than sea level, the final result must be corrected from standard conditions of 14.7 lb. and 60 deg. F. to the actual conditions of the installation, if the flow is desired in cubic feet of free air.

Water is practically incompressible but its density changes somewhat with temperature. The constant 0.569 of Eq. 1 is an average value for from 50 to 110 deg. F. Steam conditions of pressure and temperature are taken care of by use of the specific volume, which assumes that the steam is dry, and corrections must be made, if it is not.

Instruments Easily Recalibrated and New Constants Calculated

Plain manometers are satisfactory, if they can be read often, although a recording instrument will be

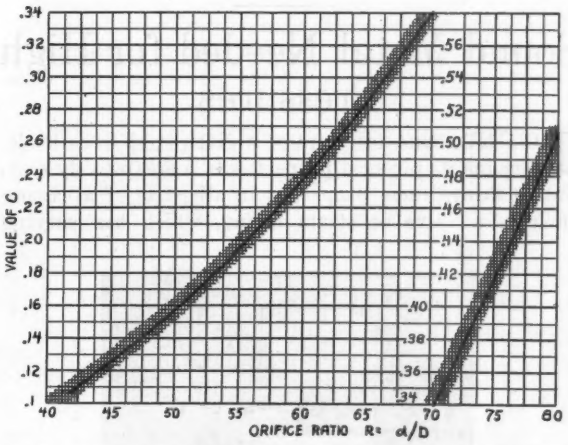


FIG. 6. ORIFICE COEFFICIENT C VARIES WITH THE ORIFICE RATIO AS SHOWN

found much more useful. In every case instruction books give the calibration in inches of water, a typical one, picked out at random, with a chart graduated 0 to 10 being:

Scale Reading	In. of Water
3	5.32
6	21.25
9	47.80

Taking the same 3-in. orifice in a 6-in. pipe as before but measuring 150 lb. gage, dry saturated steam, it is possible to work out a new calibration curve for the instrument in its new location. The specific volume of 150 lb. steam is 2.75. Substituting proper values of C, D and V in the Eq. 2, with values of h from the table, gives steam flows of 2844, 5688 and 8532 lb. of steam per hour. If these be plotted against the scale reading, the points will fall on a straight line and a simple formula W = KS can be developed. S is the scale reading of the instrument and K is a constant, in this case 948. Two sets of calibration figures are given, one for use with steam and water, and one for use with air. Values differ in the two cases and care must be exercised in their use.

For compressible fluids, pressure differentials should be kept small, preferably below 1.5 per cent of the initial pressure in order to avoid the necessity of using correction factors. Accurate measurements can be made with high as well as with low differentials but the calculations are somewhat more complicated. Knowing the maximum pressure differential allowable and estimating the flow, Eqs. 1, 2 or 3 may be transposed and the orifice size necessary for certain conditions found by solving for C and using Fig. 6.

Elbows and bends should be avoided and it is well to keep all orifice installations at least 10 or 12 pipe diameters from them, if possible. As with any other instrument or equipment, home-made apparatus is not recommended for permanent installations, as extreme care must be taken with the manufacture and installation, if the desired accuracy is to be obtained. For temporary use, however, there is no instrument which is so simple, so easily applied and so cheaply constructed and the engineer who uses one a few times to gain experience and confidence will find the flat plate orifice almost indispensable for use around the plant.

Sound Metal Needed for High Pressures

TO GET sound test bars of a given steel so as to determine its physical properties is comparatively easy, but to insure these properties in all parts of a casting such as a valve or steam fitting, which has varying

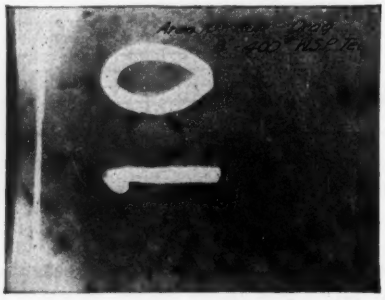


FIG. 1. X-RAY PHOTOGRAPH SHOWS HIDDEN DEFECTS IN STEEL FITTING

thickness is much more difficult. Furthermore, it is a problem to detect small flaws and variations of density in the metal, since these may not be sufficient to show under pressure test or even to be dangerous in use, yet they do somewhat weaken the casting and affect its dependability under long-continued use at high temperature and under high pressure.

To determine the condition of metal in high-pressure fittings, a series of etching and X-ray tests was undertaken at the Watertown Arsenal under the direction of Dr. F. C. Langenberg with Dr. H. H. Lester assisting. Great care was, of course, necessary, also many comparisons of X-ray exposures with etched and unetched cross-sections to determine defects and their causes. Tubes were used whose rays would penetrate 3 in. of solid steel and it was necessary to use them in a lead-lined room, operating the tube from the outside, in order to protect operators from the effect of the rays. Observations of the tube and specimen during exposure were made by means of a periscope having double reflectors faced with lead glass. All of which shows the care and precautions necessary in determining whether steel castings were entirely sound.

In the investigation a number of fittings were surveyed, 20 to 30 exposures being made of each, so as to go over the entire interior structure. Figure 1 is a typical exposure from the run near the flange of an 8-in. tee for 400 lb. working steam pressure. The number 10 and the light line at the left were lead wires used to indicate the location of the exposure on the tee and the position of the fillet at the base of the flange. Dark spots indicate defects in the casting, largely gas and sand pockets.

Sections were then cut through the three flanges of the tee and unetched surfaces showed no visible defects.

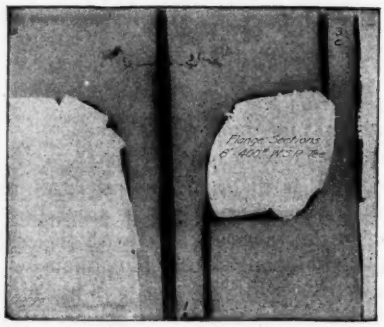


FIG. 2. INVISIBLE SURFACE DEFECTS IN SECTIONS ARE REVEALED BY X-RAYS AND ETCHING

On exposure to the X-rays, however, the results of Fig. 2 were obtained, indicating small surface cracks and porosity. On etching the sections for an hour in strong, boiling acid, the defects showed on the surfaces.

The fittings thus tested had been carefully inspected and tested before sending them to the Arsenal and these X-ray tests disclosed defects which the experts at the Walworth foundry, where the fittings were made, had

FIG. 3. SOUND CASTINGS LOOK LIKE THIS UNDER X-RAY EXPOSURE

no idea existed. The condition indicated was not probably dangerous but the Walworth Co. was far from satisfied.

Dr. Lester summarized the causes of defects as: Gas and sand pockets due to loose dirt in the mold; gas pockets due to imperfectly deoxidized metal; sand mixed in due to cutting of mold or runners; pipes caused by failure of risers to do as expected; pipes caused by slow flow of metal through narrow channels in the casting during final solidifying; cracks; and bad welds.

Here were the things to be overcome in order to get entirely sound castings and Dr. Lester stated that when these were corrected by changes in casting methods they would stay corrected so that 75 to 90 per cent of the major defects would be eliminated. This was a challenge to production skill which resulted in 6 mo. of experimenting at the foundry, changing equipment, proc-

esses, method and practice. Success was achieved, however, and the result is indicated in the X-ray photograph, Fig. 3, of the same area as Fig. 1 of an 8-in. tee for 400 lb. pressure, with no interior defects showing. Photographs and etchings from the flanges also showed freedom from defects, indicating the improvement resulting from the research and improvement in methods. Steel made by this new method is given the name Walworth Sigma Steel, which signifies that castings bearing its mark are produced by the new method with resulting soundness and dependability. Fittings and valves have been developed, conforming to American Steel Flange and Fitting Standards, for 250, 400, 600 and 900 lb. working pressure at temperature of 750 deg. F.

Motor Operated Valves Aid Plant Operation

PRINCIPAL DETAILS OF VALVES AND CONTROLS, COSTS OF INSTALLING AND SEVERAL INTERESTING APPLICATIONS ARE DISCUSSED

IN A PREVIOUS issue*, the advantages and some of the important characteristics of motor-operated valves were discussed. For that reason, we shall confine ourselves here to some discussion of details of typical valves, motor operation and control methods now in use.

Valves are now being designed by the valve manufacturers especially for motor operation. Some valve manufacturers are designing and assembling the whole unit, with the exception of the motor and some of the electrical equipment; others prefer to build the valves only and to equip them with suitable supports for mounting the driving unit, which is made complete in several sizes by other manufacturers.

Design of Valves for Motor Operation

Design of a high pressure gate valve for motor control involves several features not found in most hand operated valves. A motor-driven valve, especially when operated by remote control, must function perfectly at all times. This is true, of course, of a hand operated valve but here the operator can easily recognize difficulties, if they occur while he is operating the valve. Under remote control, this is not so easy, because the signalling system will indicate only the opening or closing of the valve, unless indicators are used. The whole unit, therefore, valve as well as motor drive, must operate perfectly.

Particular attention is given, in the design of valves for motor operation, to the size, material and design of the stem and to the connection between stem and disc. The torque obtainable from the driving motors is high and without proper design a motor might pull the stem out of the disc.

Friction occasioned by the heavy stresses that may occur is minimized by ball bearings. Machined guides in body and disc are used sometimes in hand operated valves but are considered essential in motor-operated valves. The side thrust in a large valve that is being closed under pressure is tremendous; proper guidance, large bearing surface for the discs to reduce unit pressures on bearing surfaces and self alining ball bearings will reduce the friction caused by this thrust. Hand wheels are usually of cast steel and are designed to give the requisite strength with minimum cross section and weight to reduce flywheel effect. Figure 1 shows a typical high pressure O. S. & Y. wedge gate valve designed with the above features in mind.

Sometimes, when designing a valve for motor operation, a shear pin is provided to transmit the torque from the control to the yoke nut. This pin is designed to fail at a stress slightly below the breaking stress of the stem. Certain of the motor controls provide the driving mechanism with an adjustable friction clutch which gives the same protection as the shear pin.

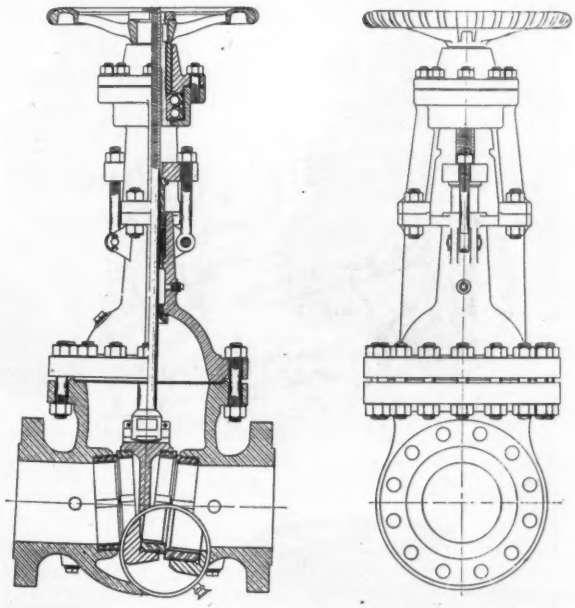


FIG. 1. LARGE HIGH PRESSURE VALVES FOR MOTOR OPERATION ARE DESIGNED WITH GREAT CARE

In many cases, as noted above, the motor-drive mechanism is attached to the valve by some sort of bracket, either made as an integral part of the valve body or arranged to be fastened to it, as in Fig. 2B. The latter arrangement allows various types and makes of valves to be equipped with suitable drive. In many cases, a user contemplates future installation of motor control, so that many manufacturers are designing all large high pressure valves for attachment of a motor control, thus obviating the necessity for purchase of a new valve.

Fundamental Characteristics of Motor Drives

Typical motor drives applied to various valves now on the market are shown in Fig. 2. They consist essentially of a driving motor, reduction gears, and some type of limit switch. Motors are usually made of the totally enclosed type for operation where steam, water or gas may be present. The whole unit, in fact, including the reduction gears and controls, is enclosed and designed for operation in the most unfavorable surroundings. Motors are small and specially constructed, in both a.c. and d.c. series types, to give high torque. This is neces-

*Motor Controlled Valves Find Wide Application, By C. W. Kuhn, Power Plant Engineering, page 474, April 15, 1926.

sary since in emergencies the valve must be operated under full pressure. In many cases, however, the valve is opened or closed with an approximate pressure balance on it, imposing a comparatively light load on the motor. Under such conditions the series motor will operate at fairly high speed, thus reducing the time of valve travel.

Valves closed while they are hot may stick on cooling. One effective method of supplying the force to start motor-operated valves under such conditions is to arrange the reduction gearing with a small amount of lost motion, so that the motor will come up to speed before picking up the load. This results in a "hammer-blow" effect that will start any valve that can be operated by motor control. Another way of securing this effect is by the use of a suitable clutch, the motor coming up to speed before the clutch has time to engage, thus producing the hammer blow.

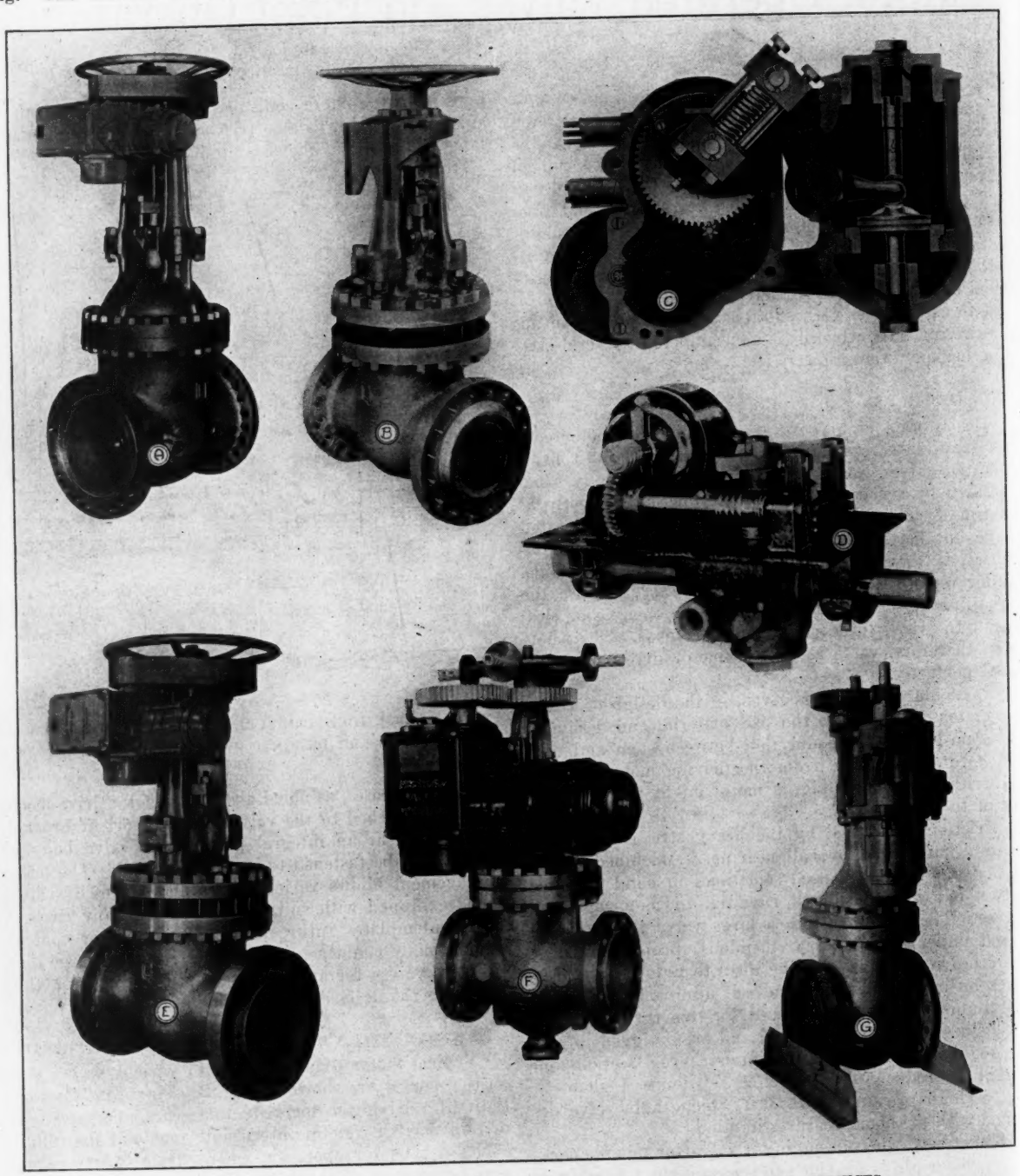


FIG. 2. TYPICAL MOTOR-OPERATED VALVES FOR VARIOUS PRESSURES AND SERVICES

A—Cast steel gate valve with motor control, designed for 400 lb. pressure. B—Hand operated gate valve with bracket for future motor control installation. C—Motor-driven single seated valve for automatic control of small lines (2½ in. and less). D—Small motor-driven pilot valve for large hydraulic valves. E—Cast steel gate valve for 900 lb. pressure. F—Another type of motor control. G—Gate valve with a third type of motor control unit.

Provision for Hand Operation

Provision is made on all types of large valves for hand operation, if necessary. This is done either by using a clutch to disconnect the motor control unit or by arranging the limit switch mechanism so that, without declutching the motor, the valve may be hand operated and the limit switches will assume positions corresponding to the amount of valve opening.

Limit switches are of various types, some being constructed to handle the motor circuits directly, while others operate control circuits to disconnect the motor from the line. To prevent drift of the motor and drive after the unit is tripped by the limit switch, positive declutching devices are used which stop the travel at the right moment and allow the motor to drift to a stop without moving the valve any farther. Electric braking is also used to stop the driving motor and prevent overtravel. In some cases, a safety clutch, set to slip just below the straining point of the valve or valve stem, is used to prevent damage to the valve under emergency conditions. In others, dependence is placed on the design of the limit switches, the main clutches and overload relays in the electrical circuits.

Most of the above comments refer to large valves used on power plant lines under medium or extremely high pressure. Some interesting types of motor-operated valves have been developed for smaller lines, however. Figure 2C shows a valve that has been developed for steam, oil, air, gas and brine lines, in sizes from ½ in. to 2½ in., the smaller sizes designed for 250 lb. pressure. It consists of a single seated valve closing with the pressure and driven through bakelite and steel reduction gears by a small 110-v., a.c. or d.c. motor. The motor is usually controlled by a special type of mercury switch actuated by pressure or temperature changes, thus making the operation of the valve automatic to give accurate control of the material flowing in the pipe lines. Figure 2D shows another small motor-operated valve designed primarily for ammonia liquid lines and as a pilot valve for large hydraulically operated valves.

Control Systems

Control systems for large motor-operated valve installations are worked out with great detail in many stations. Most systems on the market now permit operation of a valve from a number of points. In one system, the valve can always be operated to close, regardless of the position of the other stations. In others, a master station can assume control of the valve, even though the unit has been set in operation from another station, or the valve can be closed from the master station and cannot be operated again until this station is released by hand. Indicating lamps are used at the control stations to indicate the positions of the valves. Valve opening indicators can also be used, showing how much the valve is open. Elaborate control boards have been worked out in many stations for handling valves from a central point, Figs. 4B and 4C being typical examples.

Modern types of motor controls may be installed (material and labor) for approximately $400 a valve for high pressure valves 2 to 4 in. in size, for $500 to $600 in the case of valves from 5 to 10 in. and for approximately $1000 in the larger sizes. This is for the controls only, exclusive of valves. For water and gas valves the costs are usually lower, since the pressures are lower and 40 or 60-in. valves may be equipped with controls as cheaply as smaller high pressure steam valves. The chief expense for maintenance, aside from the small amount of oil and grease required, is for periodical inspection and testing. This is most important, of course, where valves are operated infrequently under normal service conditions or where the controls are intended for emergency service only.

Closing Time of Valves

Closing time of motor-operated valves is a question much discussed by engineers; it will depend necessarily on the size of the valve, pressure involved and desire of the user. Because of reactive pressures set up in steam lines and water hammer in water lines, too sudden closing is not desirable. One authority states that for carefully machined gate valves with ball bearings for the yoke nuts an average speed of 20 in. a minute for steam

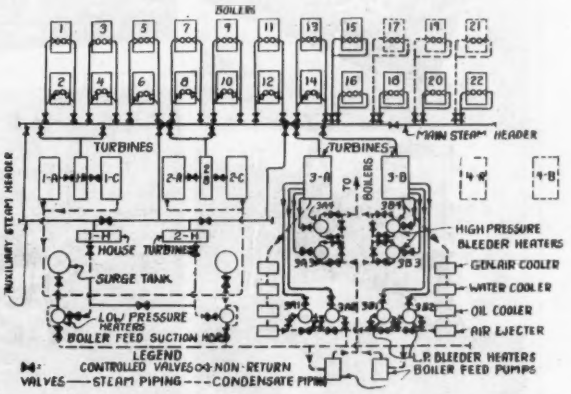


FIG. 3. DIAGRAM SHOWING LOCATION OF MOTOR-CONTROLLED VALVES IN CENTRAL STATION THAT USES 101 OF THEM

and water service is often used. Small valves, says another authority, may be closed in 15 sec. or less, while large high pressure valves are often designed to close in 2½ min. or more. Obviously, the higher the speed the less the torque available. Good practice, therefore, dictates a sacrifice of speed in favor of dependability. It is better, in short, to be sure of closing in 2 min. under extreme conditions than to take chances of stalling the valve only partly closed at a higher speed.

Figure 4 shows some typical applications of large motor controlled valves. They are, of course, applicable to pipe lines handling almost any fluid or gas. Condenser circulating water lines, central refrigeration brine lines, sewage disposal lines, oil, gas or chemical lines—the list is endless. Motors and control stations are made water proof, explosion proof or in any other manner to fit the conditions under which they must operate, particularly under emergency conditions.

Figure 4E shows a group of reheat valves on the reheat piping of a large turbine in a central station. The photograph shows one 26-in., one 30-in. and two 15-in. motor-operated valves. In addition to the usual control stations, interlocking switches geared to the valves prevent the closing of one pair of valves before the other pair is opened. The 15-in. valves at the right are on by-pass lines and, when open, allow steam to go from high pressure stages to the low pressure stages without

reheat. When these are closed and the 26-in. and 30-in. valves opened, steam goes from the high pressure cylinder to the reheat boiler and returns to the low pressure cylinder. Since it would be undesirable to close the 15-in. bypass valves before the reheat valves were opened, when changing over to reheat, the interlock switches were added.

Figure 4F shows three motor-driven valves on high pressure boiler leads. The two outside valves are boiler leads from the superheater; the middle one is a tie line from two parallel leaders. In the event of an accident the two boiler lead valves could be closed and the central valve could isolate to either side.

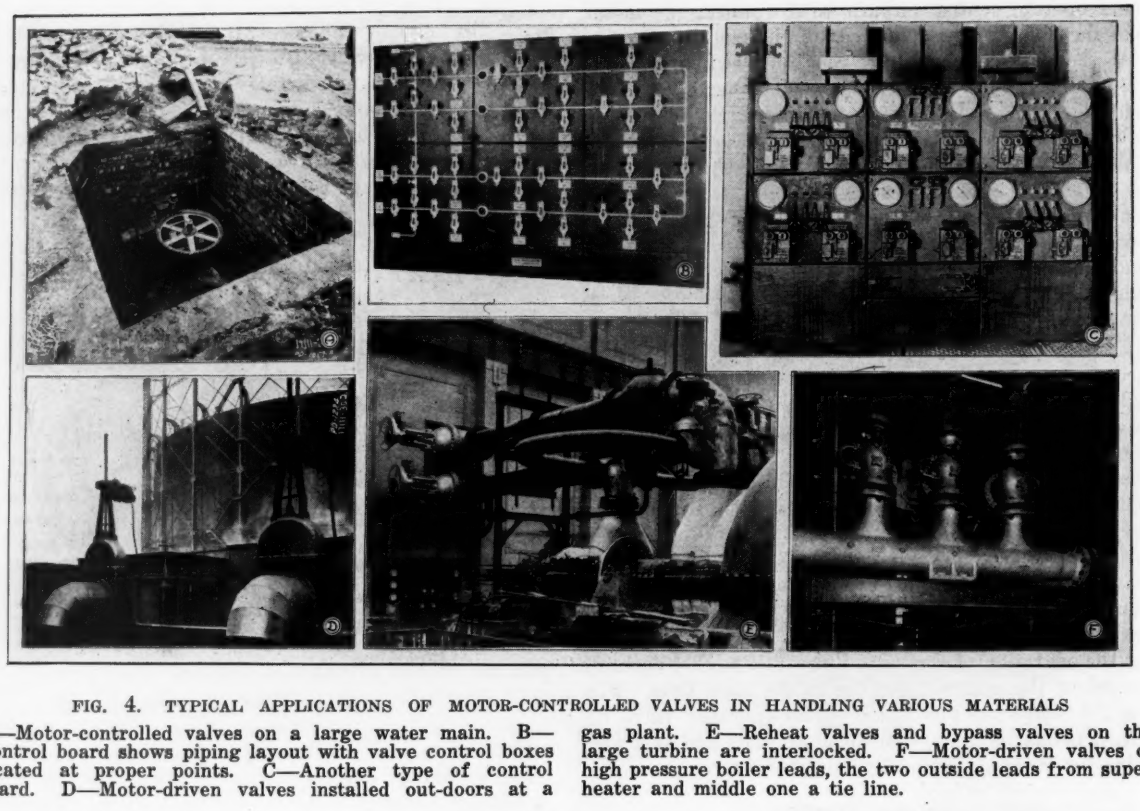


FIG. 4. TYPICAL APPLICATIONS OF MOTOR-CONTROLLED VALVES IN HANDLING VARIOUS MATERIALS

A—Motor-controlled valves on a large water main. B—Control board shows piping layout with valve control boxes located at proper points. C—Another type of control board. D—Motor-driven valves installed out-doors at a gas plant. E—Reheat valves and bypass valves on this large turbine are interlocked. F—Motor-driven valves on high pressure boiler leads, the two outside leads from superheater and middle one a tie line.

Typical Large Central Station Installation

Figure 3 shows diagrammatically one of the largest layouts of electrically controlled valves in this country, installed in a large central station. At present, there are 101 units installed, which, with the elaborate accessory control equipment, represent a total value of approximately $100,000.

From the centralized control board each pair of boiler lead gate valves is closed simultaneously from one push knob station with separate indicating lights for each valve. The same applies to each pair of turbine lead valves. All valves are opened and closed from local wall stations.

The bleeder heater control system employs 32 control units on 8 bleeder steam valves and 24 condensate valves. Each is controlled individually from local opening and closing stations. A gage board in the turbine room includes 8 push knob stations operating the 4 valves for each of the 8 bleeder heaters, so that any of the heaters may be bypassed at will. But this involves a special sequence of operation to prevent possible damage to the heaters. When the push knob for any heater is depressed, the steam inlet valve starts to close and the condensate bypass valve to open. When the latter is one-half open a special interlock closes the condensate inlet and outlet valves. To prevent serious damage to the main turbines, if the steam pressure on any heater should fail, permitting the condensate to back up into the turbine, a float switch is installed on each heater. Thus, when the water level in the heater rises abnormally, the valves operate automatically in the sequence just mentioned.

By the use of a magnetic device for separating iron and steel from monel turnings when mixed, the General Electric plant at Schenectady was able to save approximately $20,000 annually in the disposal of its scrap. Approximately 70 gross tons of mixed metal turnings were scrapped each year, as no method was known of separating the high-value monel from the lower-value iron and steel. Mixed metal turnings were sold for an average price of $15 per gross ton, while clean monel metal turnings brought approximately $300 per gross ton. Many methods had been tried of separating the two kinds of scrap without success, including the use of magnetism. The magnetic method was not successful because the monel metal was also picked up by the magnet. Finally, by using a rheostat on the magnetic separator and reducing the current to a minimum, a point was reached where the iron and steel were picked up and the monel metal dropped.

Good Foundations Best Diesel Insurance

LIGHT, POORLY CONSTRUCTED FOUNDATIONS ENDANGER ALL PARTS OF ENGINE. BY J. J. McDOUGALL

SHAFT MISALINEMENT, one of the most serious of Diesel engine ills, is best avoided at the beginning by proper installation and erection. The method used in a plant erected 12 yr. ago containing four 1700-hp. and two 1050-hp. engines has been proved successful. To date no crankshaft, or other troubles caused by misalinement, have developed.

Good substantial foundations made of the best concrete free from large rock were provided on solid ground. In some cases, it is necessary to erect engines on soft ground, or ground likely to shift, in which case a large mat or concrete raft heavily reinforced with cleaned railroad rails may be provided for the foundation to rest on. Foundations should shift as an entire unit if any movement occurs and thus prevent distortion of the bedplate and shaft. Cheap foundations are a poor investment and it is quite noticeable that when large boulders have been used vibrations are not absorbed as well as with finer aggregate. One more recent foundation using large rock has, after 4 yr. of service, developed a crack 5 ft. long on one end and 20 ft. long on one side.

After the foundation was thoroughly set, the anchor bolts were dropped in holes about 6 in. in diameter and 11 ft. deep provided in the foundation for them. These bolts, 2¾ in. in diameter and 12 ft. long in this case, have a considerable duty to perform and must be securely fastened to the foundation. Tests have shown that when properly grouted, they will break before pulling out or loosening. The foundation bolts wedged in the holes with burlap are visible back of the flywheel shown in Fig. 7. Machined faces were well cleaned and shellaced before being pulled together with shrunk bolts. Great care must be taken to make these joints oil tight

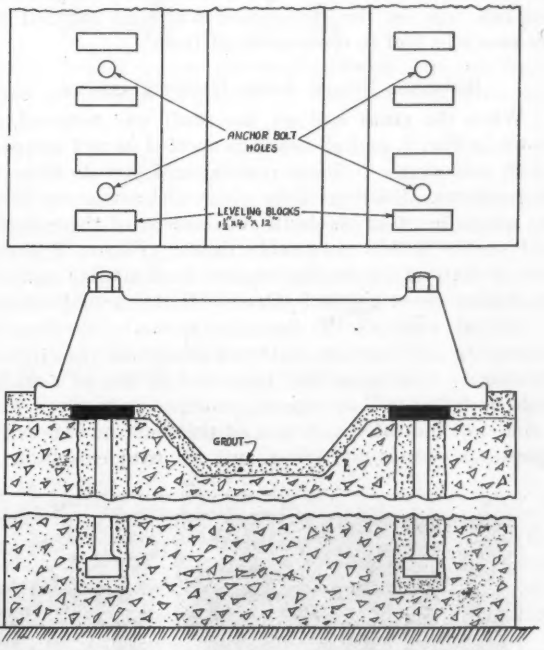


FIG. 1. PLAN AND SECTION OF FOUNDATION SHOWING BOLTS AND GROUTING

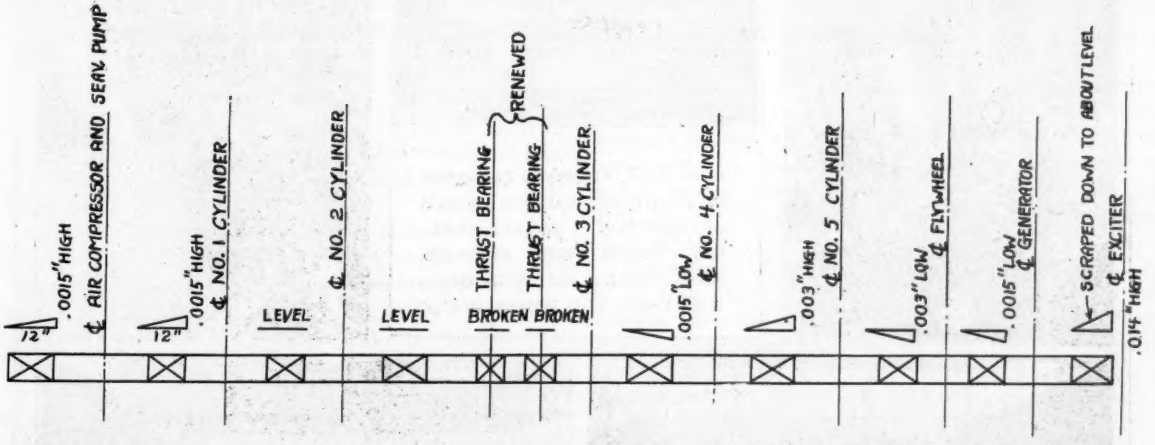


FIG. 2. CONDITION OF BEARINGS AS TAKEN BY A SENSITIVE LEVEL AFTER ABOUT 40,000 HR. ACTUAL SERVICE

in Fig. 3, which also shows the top and sides of the foundation in the distance.

JOINTS IN BEDPLATE SHOULD BE OIL TIGHT

With the exception of about 6 in. on each side of the anchor-bolts left smooth for leveling blocks, the foundation was well roughened on top before the bedplate was lowered to be roughly lined and leveled. Sections of the bedplate being lowered on the foundation are in order to prevent oil seeping through and weakening the foundation.

After roughly lining up the bedplate well mixed grout was poured round the bolts and let set for several days before the crankshaft was dropped in, shims removed from the journal bearings and the caps tightened down solidly. Thus stiffened, the bedplate was carefully leveled and tightened down on the leveling plates in such a manner that the engine could be run safely

without grouting. It is true that many large engines have been leveled up on a few wedges, grouted and have run all right and it is also true that many such engines have broken crankshafts and bearing troubles.

Leveling of the bedplate finished, it was grouted with a thin well mixed grout, care being taken that the grout, poured under a head of about two inches, flowed under the bedplate and filled all openings. Figure 1 shows how the job was done; how firmly bound the bedplate was on the foundation was well realized by the man who had to remove one of them.

Bearings Fitted After Grout Hardens

When the grout had set, the shaft was removed, as shown in Fig. 6, and all bearings spotted in and scraped, where necessary, to bring it level and free to turn in all positions. Bearings were given a clearance of 0.009 in., ample for a 12-in. shaft. Alinement of these shafts still checks within reasonable limits. Figure 2 shows how a shaft of an engine erected in a similar manner in another plant checked after 40,000 hr. actual service.

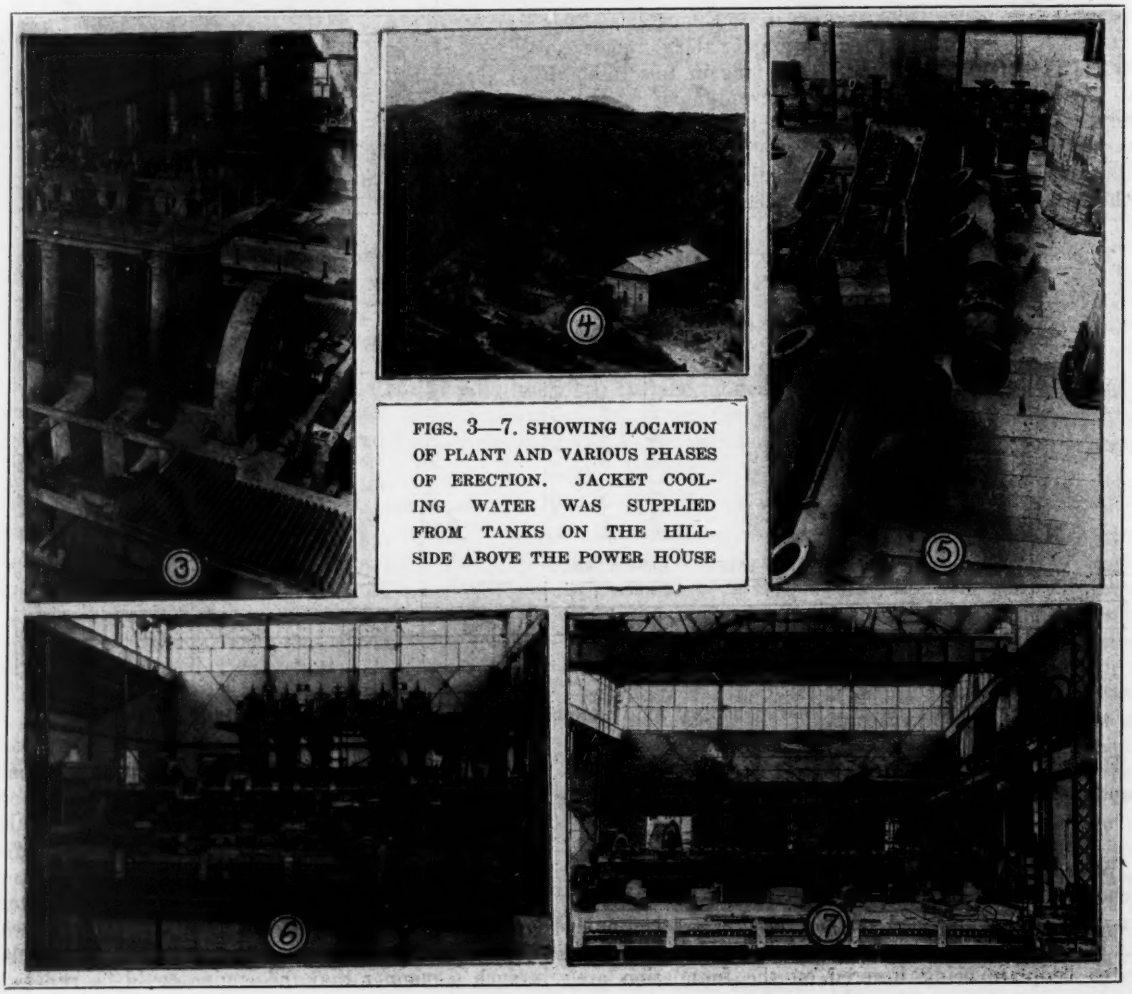
Actual wear of the bearings is easily checked by measuring the clearance and comparing with the original clearance. It is accurately measured by use of a bridge gage or better still by use of a surface gage fitted with a dial test indicator. In case of the shaft in Fig. 2, the speed was slow, only 180 r.p.m., so, with exception of exciter bearing, the alinement was considered good enough. Several journal shells were rolled out and found in good condition. Both thrust bearings were broken and the shaft had entirely too much end play. No great damage resulted from this but the connecting rods were thrown out of line, causing an enormous amount of wristpin bearing failures, which became rare after the thrust bearings were renewed.

Factors of High Efficiency in Diesel Engine

High Compression, High Piston Speed and Low Mechanical Losses Are Important

RECENTLY, before the Institute of Mechanical Engineers in London, Alan E. L. Chorlton gave results of analyses and experiments as to methods of increasing the efficiency of Diesel engines, his conclusions, as given in Engineering, pointing to the use of high compression ratio, increased piston speed and reduction of mechanical losses as the most promising lines for effort, the chief gain probably being from the first mentioned.

Dugald Clerk set the limit of compression as 10 to 1 and the efficiency limit as 39 per cent but analysis by



FIGS. 3—7. SHOWING LOCATION OF PLANT AND VARIOUS PHASES OF ERECTION. JACKET COOLING WATER WAS SUPPLIED FROM TANKS ON THE HILLSIDE ABOVE THE POWER HOUSE

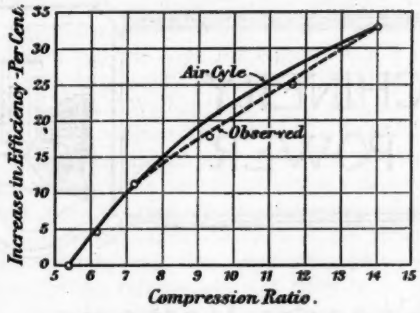


FIG. 1. AS COMPRESSION RATIO INCREASES, EFFICIENCY IS INCREASED, TESTS AGREEING CLOSELY WITH THE CALCULATED CURVE

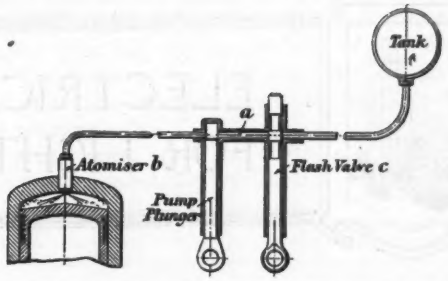


FIG. 2. ACTION OF THE CONTINUOUS PUMP AND THE FLASH SHUT OFF VALVE CAUSE QUICK FORCIBLE ADMISSION AND SHARP CUTOFF

S. W. Sparrow has shown a possible increase in power and decrease in fuel consumption up to a ratio of 14 to 1 if there is no pre-ignition.

Study of possible performance with a ratio of 13¼ to 1, a maximum pressure of 1000 lb. per sq. in., maximum temperature of 1500 deg. C. shows thermal efficiency of 64.6 per cent. Using poorer fuel of 18,300 B.t.u. per lb. gives fuel consumption of 0.216 lb. per hp-hr. with no heat losses. At 85 per cent heat efficiency the fuel becomes 0.254 per hp-hr. These figures indicate that considerable improvement is yet to be made before heat losses are brought down to 15 per cent.

Captain Sankey has taken mechanical efficiency as 75 per cent for a standard Diesel but, for faster running engines of automobile and aeroplane types, it has reached 90 per cent. Mr. Charlton feels that 85 per cent can be attained in Diesels and that tests show that mechanical loss does not increase with rise in compression ratio. With this figure, 85 per cent mechanical efficiency, and ratio of 13¼ to 1, fuel per brake horsepower is, theoretically 0.3 lb. and it should be possible to reach a fuel consumption of that order.

For internal-combustion engines, mechanical losses are, approximately: Suction, 3.4 per cent; piston friction, mostly due to rings, 6.1 per cent; bearings and other moving parts, 2.7 per cent. The piston friction, the main item, can be reduced by using higher speeds, smaller pistons and fewer rings but it will require forced lubrication to all points.

At high speeds the combustion chamber is more efficient, doubtless because of the smaller heat loss. It is necessary to get a high degree of turbulence so as to give intimate mixture of air and fuel and air blast has proved most effective but sufficient can be obtained with solid injection and the flat form of head seems to give better compression conditions than the spherical form, the solid injection is simpler than air blast but good atomization is needed which means rapid injection and instantaneous cut off of fuel with avoidance of wall contact.

To obtain these conditions, Mr. Chorlton uses a continuous running pump to move fuel back and forth from the tank, with a flash valve C, to shut off the return at the proper instant so as to force oil through the atomizer admission valve. This gives a vibratory effect, quick opening of the admission valve and a sharp, rebound closing when the shut-off valve is opened.

Commenting on the subject, W. A. Tookey cited the rise in thermal efficiency of internal-combustion engines from 24 per cent when compression pressure was 60 lb. to 48 per cent at 450 lb. At the same time, strength of mixture has a marked effect on efficiency at any given pressure.

Results of tests for both light and heavy oil engines shows better practical efficiency with 4-stroke than with 2-stroke cycle, probably because of better scavenging.

Up to 80 B.t.u. per cu. ft. of cylinder volume, greater mixture strength gives better efficiency and greater capacity, also higher mean pressure and this, Mr. Tookey believed, was the direction of progress for future design. Indications are that increasing compression ratio up to 20 to 1 will result in increase of efficiency.

D. R. Pye was doubtful that a ratio above 12 to 1 will be of value, because of difficulty in burning the fuel and W. J. Stern pointed out that mechanical losses increase with load especially when a peaked explosion is used. In a Benz one-cylinder engine, the friction was practically doubled at full load.

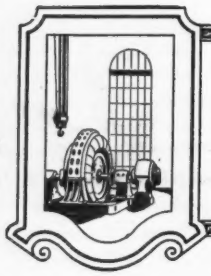
Captain Phillips called attention to increase in weight per horsepower with compression ratio above 15 to 1, which offsets the gain in economy and results, on the whole, in increased cost of power. Higher jacket temperatures will decrease piston friction because of lowered viscosity of the oil.

Mr. Chorlton said that, in practice, he does not use a ratio of over 12 to 1 and that tests at 263 brake horsepower had shown fuel consumption of 0.35 lb. per hp-hr. A mean pressure above 80 lb. per sq. in. is not needed and 70 lb. gives good results. He had used up to 120 lb. but got no increase in economy above 80 lb.

Importance of better lubrication was emphasized by H. S. Hele-Shaw particularly for higher pressures and speeds. Records on 44 large Diesels showed that the cost of lubrication was one-tenth the cost of operation but the present methods of recovering the oil, which must be used copiously, and reclaiming it makes a great saving.

THE BOSS told me, "Your salary is the difference between what you earn for me and what you cost me in supervision and losses. If your salary is to be greater your output and ability must increase or else I must get higher prices for my product. Otherwise school couldn't keep."

GERMAN POWER plants produced in 1925, 11,890,000,000 kw-hr. as against 9,050,000,000 in 1924 and 7,850,000,000 in 1923.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Good Service Includes Steady Voltage

STUDY OF SERVICE LINES AND USE OF RECORDING INSTRUMENTS ARE PRINCIPAL AIDS IN SOLVING VOLTAGE COMPLAINTS. BY VERNON W. PALEN

DESPITE all precaution, voltage complaints confront every electric service company in the field today. It is the purpose of this article, therefore, to outline briefly an eastern company's methods for handling voltage complaints with dispatch and accuracy.

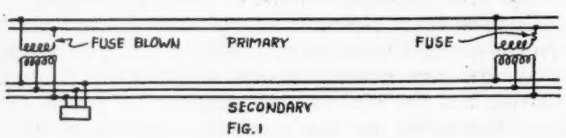


FIG. 1

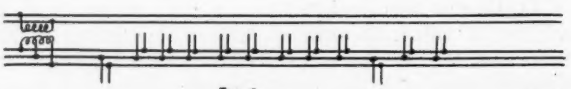


FIG. 2

FIG. 1. A BLOWN FUSE IN A BANK OF TRANSFORMERS MAY CAUSE LOW VOLTAGE IN SECONDARY

FIG. 2. HIGH VOLTAGE MAY BE CAUSED BY AN UNBALANCED SECONDARY CIRCUIT

Of the complaints received over a period of six months, fluctuating voltage complaints made up 60 per cent of the total, while low voltage complaints comprised 15 per cent and high voltage complaints 5 per cent. The remaining 20 per cent was made up of complaints which were apparently unjustified.

Usually the type of complaint (whether fluctuating voltage, low voltage, or high voltage) immediately suggests the possible sources of trouble. For instance, a low voltage complaint may be caused by the following conditions:

1. Primary fuses blown on one of a set of banked transformers.
2. Loose connection.
3. Secondary of excessive length.
4. Secondary of inadequate cross section.
5. Low voltage on primary feeder.
6. Overloaded transformer.

Before leaving the office to investigate a low voltage complaint, therefore, it is well to check up whether the primary feeder voltage is normal, to find out the load on the transformer, to ascertain whether the complainant's transformer is banked with another transformer and to obtain a sketch of the secondary layout. In many cases with this procedure one can locate the source of trouble before leaving the office.

In the case of banked transformers the condition shown in Fig. 1 occurs. Under these circumstances the consumer is being fed over a secondary much longer than normal and usually low voltage will result.

Many clues to the cause of a complaint may be gathered by questioning the complainant. Where trouble results after line work has been done the trouble may be traced to a loose connection. Often the complainant's statement that the trouble developed since the men worked on the lines saves time and money. A troubleman can soon locate the faulty splice.

Where small secondary copper (such as No. 2 or No. 6) is used, a consumer sometimes receives low voltage due to excessive voltage drop. It is good practice to limit the length of single line secondary to 1000 ft. and to loop around a city block whenever possible. Whether to replace existing secondary with heavier secondary such as No. 00 or to hang an additional transformer to pick up half the load is often a matter to be determined by local conditions. If the section is growing rapidly, adding transformer capacity will undoubtedly be the best procedure.

Low voltage on the primary feeder may result from a blown fuse on the control circuit of an automatic regulator. Thus, the regulator may remain in full "buck" position when it should be in full "boost" position. Checking the outgoing voltage and load condition of the feeder will bring to light any trouble of this kind due to an inactive regulator.

The number of low voltage complaints resulting directly from overloaded transformers is almost negligible since the regulation of a transformer is very good up to 125 per cent load. Few cases develop where a transformer becomes overloaded more than 15 per cent or 20 per cent. Only where the transformer is small does the voltage drop appreciably due to overload, therefore, in rare cases only does trouble result in this manner.

High voltage complaints usually result from the following conditions:

1. High voltage on primary feeder.
2. Wrong transformer taps.
3. Unbalanced load on secondary.

As with low voltage complaints, it is well to find whether the primary voltage is normal since it sometimes occurs that an automatic regulator gets stuck in the full "boost" position. As the load drops off, the regulator is unable to change to the "buck" position and so high voltage results.

Perhaps high voltage results most frequently through the use of wrong transformer taps. To illustrate, sup-

pose that growth of a community requires that additional transformers be hung. Since most standard transformers provide taps for either 10 to 1 or 9 to 1 voltage ratio, it is easily possible for the lineman to use the 9 to 1 taps. With a primary voltage of 2300 v., high secondary voltage results and a complaint is received. The complainant may state that the trouble has been present since the new transformer was hung. That statement gives the first clue to the cause. A voltmeter reading will perhaps indicate 130 v. at the complainant's residence. When load (an electric flat iron) is turned on, probably the voltage will not drop more than 2 or 3 v., showing that there is no unbalance due to a broken neutral. A voltmeter reading off the nearest secondary fed from a transformer on the same phase and same primary as the complainant's transformer is finally taken. The voltage no doubt will be 115 v. or thereabouts. A troubleman sent to reconnect the taps on the faulty transformer will undoubtedly find conditions as they were anticipated from the above-mentioned tests.

High voltage may be due to the condition shown in Fig. 2. Thus a large proportion of the total load on one side of the secondary will cause the lightly loaded side to have high voltage. This condition occurs rarely

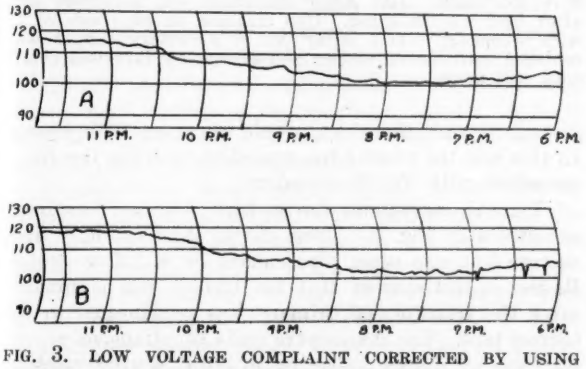


FIG. 3. LOW VOLTAGE COMPLAINT CORRECTED BY USING LARGER SECONDARY WIRE

Charts made at complainant's residence. (A) Left leg to neutral. (B) Right leg to neutral.

now since three wire consumers' services are becoming more common.

High voltage is usually discovered from its effect on electric light bulbs. The shortened bulb life attracts the attention of the consumer who then knows something is wrong. In a few instances short life of electric light bulbs has been unjustly attributed to high voltage. In these cases the short life was due to the use of a cheap grade of lamp or to use of 105-110-v. bulbs on 115-120-v. circuits.

Flickering light complaints may result from the following conditions:

1. Motors on lighting secondary.
2. Unbalance due to broken neutral.
3. Primary trouble.

Flickering light complaints make up the greater part of the total complaints received. Usually, the cause of the flickering is found to be a motor on 110 v.; sometimes the motor is on 220 v.

Rarely does the flickering occur while the company representative is present. On this account it is necessary to install two recording voltmeters at the complainant's residence and one at the first consumer off the transformer. Two meters should be installed at the complainant's residence, when three wire service exists, since the motor dips may be on one side of the secondary only. The meter at the first consumer off the transformer will show whether or not the voltage dips are on the primary.

In many cases, when the charts are received with voltage dips recorded, the type of dips, together with the

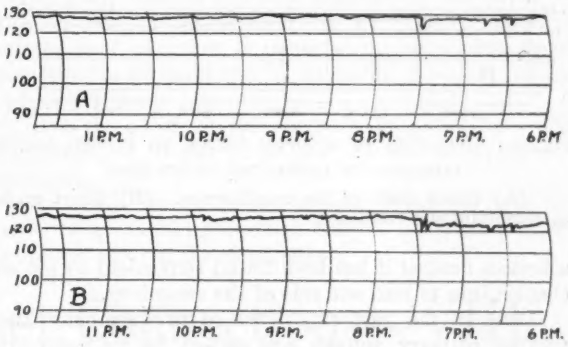


FIG. 4. CHANGING TRANSFORMER TAPS CORRECTED THIS HIGH VOLTAGE COMPLAINT

Charts made at complainant's residence. (A) Left leg to neutral. (B) Right leg to neutral.

time and the frequency of occurrence, often indicate the type of motor to look for in making a search of the neighborhood. When the troublesome motor is located, a motor load test is made. If the starting current is greatly in excess of the company requirements, the owner must reconnect the motor for 220 v. or replace it with a 220-v. motor (if motor cannot be reconnected). Where the starting current is only slightly larger than the specified value and where the dips are comparatively small, it is the policy of this company to replace No. 2 with No. 00 copper where this will remedy the trouble. Instantaneous variations in voltage of not more than 2 v. on 110-v. circuits or 4 v. on 220-v. circuits are not considered objectionable.

The number of flickering light complaints arising from small motors is growing rapidly. With fractional

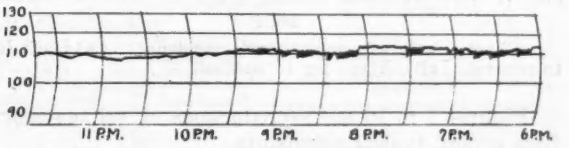


FIG. 5. THESE DIPS WERE CAUSED BY A SEWING MACHINE MOTOR

Chart made at complainant's residence.

horsepower motors finding an ever increasing field of usefulness in the home it becomes correspondingly important that the "split phase" motor go and that motors be connected only on 220 v.

Fluctuating voltage may result from a broken neutral and this condition may be easily discovered by putting load on one side of the secondary. If the neutral is broken the voltage will drop to 80-90 v. on one side with a subsequent rise in voltage to 130-140 v. on the opposite side of the three wire secondary. Here again the complainant may give the first clue to the trouble by stating "the lights change brilliancy whenever load is turned on and off." In making the test for

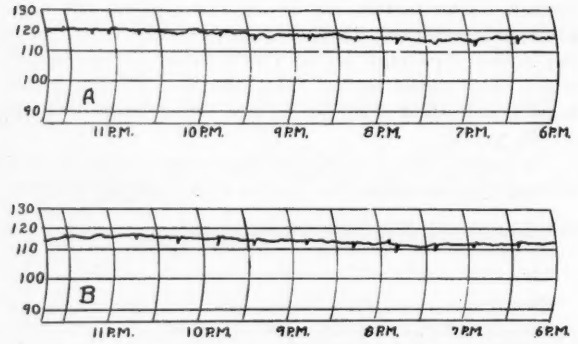


FIG. 6. CHANGING FROM OPEN DELTA TO CLOSED DELTA CONNECTION CORRECTED THESE DIPS

(A) Chart made at the transformer. (B) Chart made at complainant's residence.

a broken neutral it has been found convenient to use an electric iron to load one side of the secondary.

Once in the past experience of this company fluctuating primary voltage was caused by an automatic pumping plant receiving power from an open delta transformer bank. The motors started every half hour and caused a dip that was felt on all the secondaries in the surrounding neighborhood. The trouble was remedied by replacing the open delta bank with a closed delta bank.

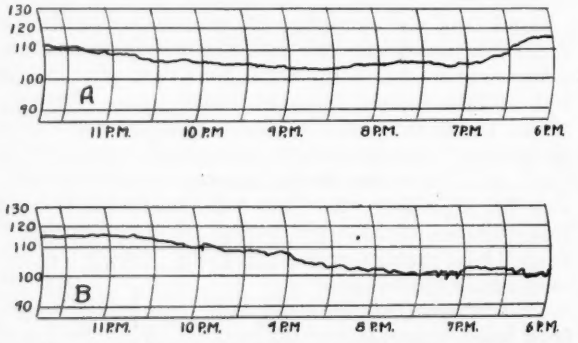


FIG. 7. LOW VOLTAGE CAUSED BY EXCESSIVE SECONDARY DROP

Charts made at complainant's residence. (A) Left leg to neutral. (B) Right leg to neutral.

Figures 3 to 10 are reproductions of voltage charts from several typical complaints.

Figure 3 shows a low voltage complaint caused by excessive secondary voltage drop. As will be seen, these two charts were made simultaneously, so as to show the

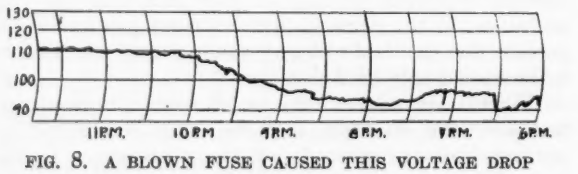
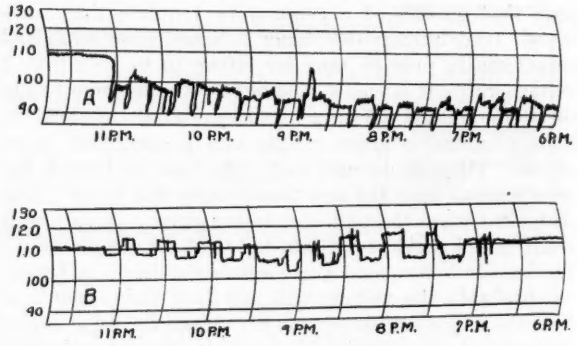


FIG. 8. A BLOWN FUSE CAUSED THIS VOLTAGE DROP

Chart made at complainant's residence.

voltage conditions on both sides of the secondary. Not only do the charts show that the voltage is low but also that the dips are caused by a 110-v. motor. Dips caused by a 220-v. motor occur on both sides of the three-wire



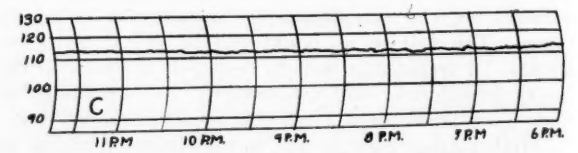


FIG. 9. THIS VOLTAGE FLUCTUATION WAS CAUSED BY MOTION PICTURE MACHINES

All charts made at complainant's residence. (A) When complaint was received. Both machines on one side of 3-wire secondary. (B) After secondary was shortened and after load was balanced. One machine on each side of 3-wire secondary. (C) After No. 6 secondary copper was replaced with No. 00 copper and after secondary was shortened still more.

secondary and, therefore, would show on both charts. In this case the trouble was remedied by replacing No. 6 secondary with No. 00 secondary.

Typical conditions for a high voltage complaint are shown in Fig. 4. These charts show not only high voltage but also some dips caused by a 220 v. motor. Re-test charts showed that the trouble was eliminated after the transformer primary was reconnected to the correct taps. The charts were made simultaneously.

Dips in voltage cause by a 110-v. sewing machine motor are shown in Fig. 5. The frequency of the dips indicates that the starting and stopping of the motor occurs very frequently. With a little careful analysis one could have guessed that a sewing machine motor was causing the trouble. This trouble was finally rectified after the troublesome motor had been replaced with a 220-v. motor.

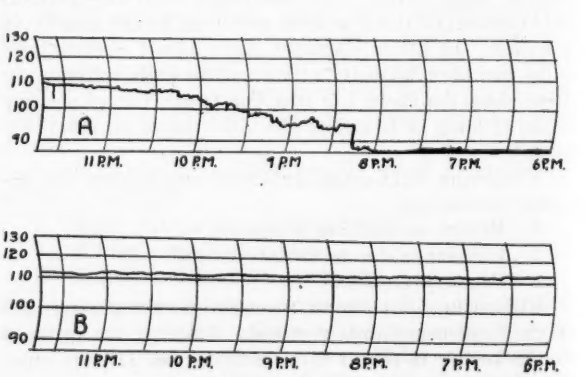


FIG. 10. CONDITIONS BEFORE AND AFTER REPLACING SECONDARY LINE

Charts made at complainant's residence. (A) When complaint was received. (B) After secondary copper had been put in.

Figure 6 shows charts illustrating voltage dips traceable to the primary. These dips were caused by an automatic pumping plant receiving power from an open delta transformer bank as mentioned above. Charts were made simultaneously.

Inadequate copper cross section caused the low voltage condition shown in Fig. 7. Again, the trouble was removed by replacing No. 6 secondary with No. 00 secondary. These charts were made simultaneously.

Figure 8 shows the condition resulting from a blown transformer fuse on banked secondaries. This condition was remedied through replacement of the blown primary fuse.

Two motion picture machines caused the extremely bad voltage condition shown in Fig. 9. The trouble was remedied through the combined effect of placing the machines on opposite sides of the secondary and through shortening and increasing the cross-section of the secondary copper. The charts show the improvement in voltage condition experienced after each step in the process had been completed.

Figure 10 shows low voltage traceable to secondary of excessive length. The conditions existing before and after No. 6 copper had been replaced with No. 00 copper are clearly brought out.

In conclusion, the importance of interviewing the complainant cannot be emphasized too strongly. Much helpful information has been obtained by the writer in this manner. In all cases where the evidence obtained on the first interview is doubtful or insufficient proof that trouble exists, it will be advisable to install recording voltmeters.

It is the policy of this company to install recording voltmeter for re-test after the trouble is supposedly remedied.

As will be readily seen, much can be learned as to the cause of a complaint through careful study and interpretation of what the charts show.

Principles of Transformer Connections—VIII*

SPECIAL TYPES OF TRANSFORMERS, TRANSFORMER ACCESSORIES AND PROTECTIVE DEVICES. BY V. E. JOHNSON

CONSTANT current regulators consist essentially of a transformer, in which the secondary current is kept constant by the mechanical movement of portions of the electrical or magnetic circuit, or by means of a special arrangement of the magnetic circuit. A regulator of the former type is shown in Fig. 1, the moving parts being drawn schematically.

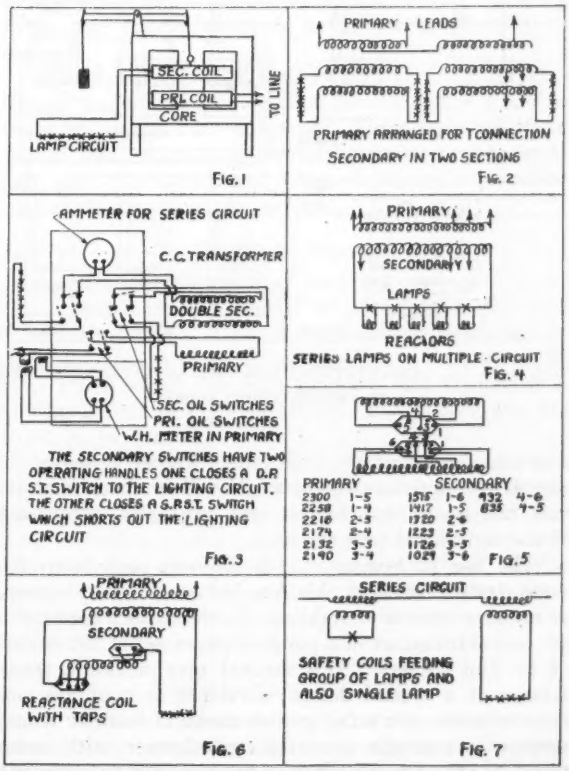
In order that these regulators may be suitable for operation on primaries that vary somewhat from the standard, taps are provided, on the primary coils, in exactly the same manner as in ordinary constant potential distribution transformers. Taps are also provided on the secondary, or constant current side, so as to obtain better characteristics when operating at partial loads. These taps are usually brought out in the form of leads, to which the lines are connected.

If two constant current regulators are to be operated on a three phase bus, balanced operation may be obtained by using a T connection on the primary, assuming that a proper tap arrangement is available. This consists of 50 per cent and 86 per cent taps and the scheme employed is exactly that on which the well known Scott connection is based. Figure 2 shows two units connected in this manner.

The secondary of a constant current transformer is sometimes divided into two circuits, each supplying half of the total lighting load. This reduces the potential stresses under abnormal conditions, such as a ground on one side, and is quite standard construction on the larger ratings where the terminal voltage is high. If it is desired to split the circuit into sections so as to avoid total outage in case of trouble, or to take care of 'half night'' circuits, switches must be provided to control these parts. Figure 3 shows the arrangement of a typical street lighting panel, with the connections made to the external circuits.

Street lights are sometimes connected in series without the use of any constant current regulator. In this case, outages are taken care of by means of reactors, connected in shunt with each lamp. As long as the lamp burns, little current flows through this bypass, but when the filament breaks, the entire current passes through it, creating a drop which closely approximates the terminal voltage of the lamp. Thus the failure of a reasonable proportion of the lamps in the circuit has very little effect on the balance of the units.

Such an arrangement requires that the transformer

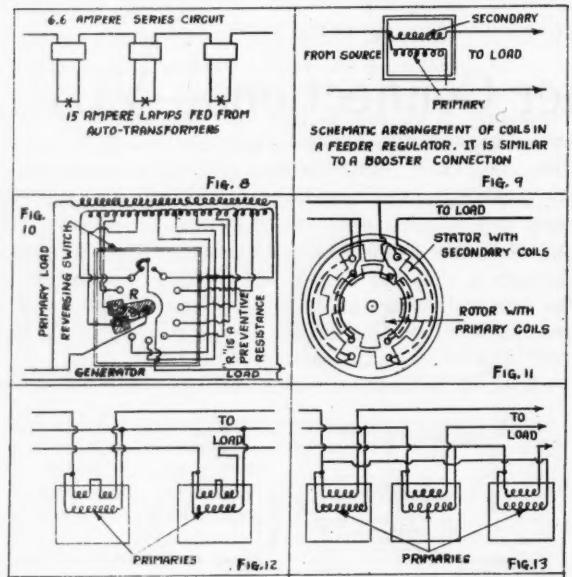


FIGS. 1 TO 7. SCHEMATIC DRAWING OF CONSTANT CURRENT REGULATOR AND VARIOUS CONNECTIONS IN COMMERCIAL USE

*Previous articles of this series appeared in the following issues of Power Plant Engineering: Sept. 15, 1925; Nov. 1, 1925; Dec. 1, 1925; Feb. 15, 1926; April 15, 1926; June 15, 1926 and Aug. 15, 1926.

which serves as the supply have taps brought out so that the original ampere flow can be properly adjusted. Units are especially designed for this kind of service, the standard apparatus operating from a 2300-v. primary. The secondary voltage is determined by the lamps to be operated, and may be either lower or higher than the primary. In either case, taps are provided to give a wide range of adjustment. The primary coils are also tapped, so that between the two, a fine adjustment of secondary voltage may be obtained.

Figure 4 shows a schematic arrangement of the coils in a transformer for this kind of service. It will be noted that the tap at the left hand end of either of the windings has only half of the value of one of those at the right-hand end. Thus "half steps" may be obtained by cutting this tap into service between succes-



FIGS. 8 TO 15. CONNECTIONS FOR THE AUTO-TRANSFORMER AND FEEDER REGULATORS

sive connections of the full taps. Figure 5 shows the complete connection diagram. It will be noted that the half tap is cut into circuit and out again, after each of the right-hand taps are used.

The use of reactance coils around each lamp has some drawbacks, and this has led to the development of another system of lighting, in which the reactance is all concentrated at one point, outages being taken care of by film sockets. This method may utilize a transformer of a special design, arranged to maintain constant current over a fairly wide range of load, or it may employ a constant potential transformer with many taps (like the one discussed in the previous paragraphs), with the reactance in a separate unit.

Figure 6 shows a street lighting circuit with the latter type of apparatus. The connection diagram shows how taps are brought out on the reactor.

Hazards incidental to the use of high potential series lines for street lighting have brought about the use of so called "insulating transformers" or "safety coils." These are essentially ordinary transformers in appearance and design, and are connected as shown in Fig. 7. They insulate individual lamps, or groups of lamps, from the main circuit, the primary being supplied from the constant current line fed by the station transformers, while the secondary delivers a suitable current to the lamp filaments. The ratio of these transformers may be one-to-one, or the current may be stepped up to higher values, in order to take advantage of the better efficiency of the 15 and 20-amp. lamps.

It is sometimes desirable to use 15 and 20-amp. lamps, without going to the expense of insulating transformers. In that case an auto transformer as in Fig. 8 is installed—usually in the base of the street lighting post, or in the top of the street hood. These do not insulate the lamp circuit from the main series feeder.

Feeder Regulators

The necessity for varying the voltage along individual feeders to compensate for line drop, and the impossibility of accomplishing this practically by the use of ordinary boosting transformers, has led to the use of feeder regulators. These consist essentially of a variable ratio transformer, having its secondary winding in series with the line, and the primary connected across the phases, or to neutral, as the case may be.

Change in ratio is made possible in two ways, the first method (now practically obsolete) employing a step-by-step tap changing device and the second depending on a variation of the phase relations between the secondary and primary coils. Figure 9 shows the schematic connection of a feeder regulator. Figure 10 shows the approximate arrangement of the internal taps in a step-by-step regulator. The complicated construction of the face plate is required by the fact that taps must be changed under load conditions, and means must be provided to prevent destructive arcing during the period of transition, from one connection to the next. The preventive resistance shown provides a means for doing this. This type of apparatus, when controlled automatically, provided smooth operation, due to the fact that the moving parts were light and had slight inertia. On the other hand, the maintenance of the contact making mechanism was difficult, and led to a gradual abandonment of this type in favor of the so-called induction regulator.

Figure 11 shows a scheme of the connections of an induction regulator. The primary coils are wound on a movable core, the position of which determines the magnitude of the secondary terminal voltage, and also whether it is to "buck" or "boost."

A feeder regulator may be disconnected from the line without interrupting the service, by turning it to the neutral position where it neither bucks nor boosts, shorting the secondary, and opening the primary.

Figure 12 shows two single phase regulators on a three phase line. Figure 13 shows three single phase regulators on a three phase line. Figure 14 shows a three phase regulator on a three phase line. The latter type regulates all three phases equally and simultaneously, and is therefore suitable only under balanced load

conditions, such as exist on power lines. They are, however, sometimes used to maintain constant bus voltage at substations.

It is standard practice to provide the larger sizes of induction regulators with two winding secondaries, so that connections can be made either in series or parallel. Thus a given regulator may be rated at 100 amp. 10 per cent regulation, or 200 amp. 5 per cent regulation.

Three single phase regulators do not have any more current carrying capacity than two, but the regulation is greater. It therefore is not possible to take care of changing load conditions by installing two units at first, and later increasing the total rating by adding the third. An examination of Fig. 12 and Fig. 13 will show that the entire line current passes through the secondary winding, regardless of the number of units.

On three phase four wire systems, the regulators are connected as in Fig. 15. If the loads in the three phases are considerably unbalanced, better regulation can be obtained by providing for neutral line drop compensation, by means of a current transformer and compensator connected in the fourth wire.

Three-Winding Transformers

On three phase units, or in three phase banks of single phase units, a third winding is often used in connection with a star-star connection, in order to stabilize the neutral, and to prevent trouble due to the third harmonic.

Aside from this, units having a third winding are frequently used on systems which have three different voltages, as for example the typical one in Fig. 16. Here power may be transmitted from the 66,000-v. line to the 33,000-v. line, and power taken off at 2300 from either of them. The third winding is also used at times to furnish power to synchronous condensers.

Use of three-winding units, as compared to two two-winding units for similar applications, has both advantages and disadvantages. The efficiency should in general be better, due to the fact that one transformation is made to do the work of two. The first cost is somewhat lower, based on equal load carrying capacity, because of the fact that certain parts of the circuit may be doing double duty. On the other hand, when high voltages are involved, the substation layout becomes quite difficult, because of the fact that two different high voltages come from the same unit, and clearance must be maintained.

Rating of the various windings of a three-winding unit can be arranged to meet any stated condition. Thus, if all three have the same capacity, any winding can deliver the rated load of the unit. For example, one having a total capacity of 2000 kv.a. with equal capacity in each winding, can deliver 1000 kv.a. at two voltages, taking 2000 kv.a. from the line at the third. Or it could deliver 2000 kv.a. at one voltage, no kv.a. at the second, and still take 2000 kv.a. from the line at the third. It must be borne in mind that the total capacity must not be exceeded, regardless of how it is divided.

This point of rating must be given particular attention, for it is practically impossible to provide automatic apparatus that will indicate when the total capacity has been reached. Simultaneous readings of the three loads must be taken, and the sum of these must not exceed double the unit rating. Thus the 2000-kv.a. unit above might have 2000 kv.a. on the high voltage, and 1000 kv.a. each on the low and intermediate, making a "fictitious" total of 4000 kv.a. This is, of course, not the real output, but is the sum of the output and the input.

Three-winding units may be paralleled, if their characteristics are the same, and if the load conditions are right. If two of the windings are to be multiplied, while the third must carry individual loads as in Fig. 17, circulating current will result if the latter are unequal, as in that case the regulation would be unequal.

It is difficult to obtain satisfactory operation when three-winders are operated in parallel with two-winders, for the reason that the load on the unparalleled circuits will affect the regulation of the whole unit. This becomes particularly true if an attempt is made to operate two-winding units in multiple with more than one voltage of the other. The arrangement shown in Fig. 18 would be difficult to operate satisfactorily.

Three-winding transformers are valuable in many installations, but the various conditions to be met must be carefully analyzed before this type of apparatus is selected. Oftentimes the difficulties that are encountered more than offset the gain. Varying power factors on the different windings, when two are in parallel and the third isolated, may cause considerable trouble with load division.

Transformer Accessories

For convenience in changing taps from the outside of the case, transformers are often supplied with hand-wheel tap changers. These are particularly convenient on high voltage units, in which the terminal boards are submerged under a considerable head of oil. Figure 19 shows the arrangement of a typical hand-wheel tap changer.

Such apparatus must not be operated when the transformer is connected to the line, for the contacts are not designed for this kind of service. There are a number of special cases where it is desirable to change taps under full load conditions, and when these are encountered special designs must be made.

Terminal Boards

In small transformers of moderate voltage, the terminal boards usually consist of porcelain blocks, with threaded terminals, to which links may be connected for changing the ratio of transformation. Sometimes the same block serves for both primary and secondary as in Fig. 20, while in other designs two boards are provided, as in Fig. 21.

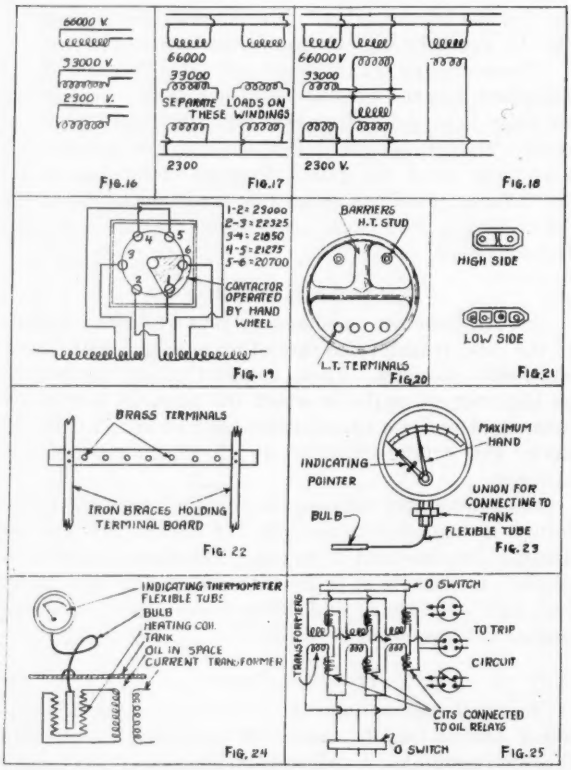
In large transformers, the use of porcelain blocks is impossible, due to the necessity of providing considerable mechanical strength, and also sufficient electrical clearance. Wooden beams are ordinarily used for this kind of service, the wood being vacuum treated and impregnated. These are supported by structural iron shapes of various kinds, and are deeply immersed in the transformer oil. Figure 22 shows this arrangement.

Temperature Indicators

In small transformers, temperature indicators are seldom used, except the kind commonly called the semaphore or flag type. It is immersed in oil, and indicates when the safe temperature has been exceeded by some kind of warning signal coming into view.

In medium sized units, temperature indicators of various kinds are used, some of them being ordinary mercury thermometers mounted in brass fittings and immersed in the oil. Others are of the dial type, and indicate not only the present temperature of the oil in the apparatus, but also the maximum temperature that has existed since the last observation. This type is shown in Fig. 23.

All of the above indicators measure the temperature of the coils indirectly by measuring that of the oil. During periods of constant load, and constant ambient temperature, a definite relation will exist between the hot spots in the coil, and the portion of the oil in which the indicator is immersed, this definite relation becoming effective only after the parts have reached constant temperature.



FIGS. 16, 17 AND 18. CONNECTIONS FOR THREE-WINDING TRANSFORMERS

FIG. 19. TYPICAL HAND WHEEL TAP CHANGER

FIGS. 20, 21 AND 22. TRANSFORMER TERMINAL BOARDS AND SUPPORT

FIGS. 23 AND 24. TRANSFORMER TEMPERATURE INDICATORS

FIG. 25. CONNECTIONS FOR DIFFERENTIAL PROTECTION OF TRANSFORMER

When a transformer has full load impressed upon it, and the oil is cold, considerable time will elapse between the time the unit is placed in service and the time when the oil at the thermometer indicates full load temperature. This lag between the actual temperature in the coil and the indication of the thermal apparatus, may under certain conditions permit operation under destructive loads, and several different schemes have been introduced to eliminate it. The most direct method would be the use of thermo-couples imbedded in the coils that are in the hottest part of the structure, but this introduces severe insulation strains, and is difficult to carry out in practice.

Figure 24 shows an indicator designed to eliminate this undesirable lag. It consists essentially of a heating coil energized from a current transformer in the main circuit. Immediately upon taking load, this heater acts on the thermometer element, so that it will indicate the internal temperatures. There will be some lag, due to the surrounding oil, but this will be nearly a counterpart of that in the coils themselves.

When the unit has reached a constant temperature, the heating coil will nearly compensate for the drop between the hottest spot and the position in which the indicator is located.

Most of the above indicating devices are equipped with contacts, which can be connected to alarm devices to give warning when safe temperatures have been exceeded.

Differential Relay Protection

An internal failure would cause damage very quickly, so that any form of protection depending on measurement of temperature, would be useless. Figure 25 shows what is commonly called the "differential protection" of a transformer. Inasmuch as the secondaries of the current transformers normally carry the same current, this connection would not operate the relays, regardless of the amount of external load. An internal failure would unbalance these secondary currents, tripping the relays, and clearing the unit from the line.

If the secondary currents of the transformers were not equal, due to differences in design or ratio, a balance transformer would be added to correct for this inequality.

Striking illustration of the advantage of Diesel engine drive over steam for pilot boats and vessels in similar service where there is a large proportion of standing time is given in the remodeling of the boat Carmania, originally built as a pleasure yacht. She is of 260 t., 168 ft. overall, 141 ft. waterline, 21.5 ft. beam and 11 ft. draft. With a 4-cylinder triple expansion engine working at 250 lb. pressure and bunkers for 60 t. of coal, she could remain at sea a week on pilot boat service. With the new outfit, installed by the Kensington Shipyard Department of the William Cramp & Sons Ship and Engine Building Co., it is expected that she can remain out 50 days.

The new plant is a 6-cylinder, 4-cycle marine type Diesel engine of 400 hp. at 277 r.p.m. and accessory equipment made by the De La Vergne Machine Co. with cylinders 14.5 in. diam. by 18 in. stroke. Solid fuel injection at 2000 lb. is made by an individual pump for each cylinder. Drive is through Falk reduction and reversing gears, a Cramp disconnecting clutch and Metten hydraulic clutches to the low-speed pinions. Falk-Bibby flexible couplings between engine and gears and between gear case and propeller shaft prevent damage due to hull or local distortion and allow slight longitudinal movement when operating clutches.

Exhaust from the engine heats the vessel by a Davis heater, an oil burner serving when the engine is shut down. There is also a refrigerating outfit with chill rooms and ice making unit.

Power and Heat for Industrial Power Plants

NON-CONDENSING PLANTS DESIRABLE WHERE PROCESS AND HEATING STEAM BALANCE A CONSIDERABLE PART OF POWER REQUIREMENTS. BY MARCUS K. BRYAN*

FOR COMPARING costs of generated and purchased power, all operating and fixed expenses should be included and it is better to compare combined cost of power and heat since it is difficult to be sure that the two are accurately separated. Factors of importance are reliability, financial return on investment, operating cost and flexibility or ability to meet growth and changing conditions. Each plant is a separate problem and its individual requirements should be carefully analyzed in making a decision.

Process steam usually comes as exhaust from non-condensing units, as bleeder steam from turbines or as live steam from the boilers and sometimes as condensing exhaust bought from a public utility plant. Where process and power requirements are equal, a condition never realized, the coal consumption for plants using non-condensing turbines, one using bleeder turbines and some live process steam, and one using condensing turbines and live process steam are shown to be in the proportions of 77, 83 and 100. But process and power demands will vary, sometimes one being higher, sometimes the other, so that this relation will not hold in practice.

Process requirements which vary may be evened up by heat storage in either a steam accumulator or a hot water system and it may often prove more economical to use a bleeder turbine or a combination of non-condensing and condensing bleeder units where process and power requirements vary considerably but not together.

Plants, such as plain-goods cotton mills, which require little process steam and large power will hardly find it profitable to use non-condensing power units at all, or even to generate their own power if low-price current can be purchased, unless a power plant is already installed which would be abandoned if current were bought from outside.

Where process requirements are in the region of 30 per cent of power requirements, the use of a bleeder type or a non-condensing unit, supplemented by purchased power should be considered. Factors in such a case are that the cost of plant per kilowatt capacity will be greater for a small unit than for a large one. If the plant has used high-pressure steam through a reducing valve for process work and heating, the piping will probably have to be changed from boiler room to reducing valve and this may run to a considerable cost per kilowatt. Also summer and winter requirements for heating steam may be quite different, so that capacity should be provided in power units to meet heat needs in winter but, in summer, they should carry only enough load to furnish the steam for process work, the balance of the power needed being purchased.

If considerable amounts of process steam are needed, the saving by this method may be substantial. In one plant using an average of 70,000 lb. of steam an hour, varying from 45,000 to 100,000 lb., and having a power load averaging 1000 kw., varying from 500 to 1400 kw., the use of non-condensing equipment to reduce steam pressure from 175 lb. to 12 lb. resulted in a net saving of $12,000 a year or 25 per cent on investment over all fixed costs. The plant complete cost about $100 a kilowatt, fixed charges and interest were taken at 12.5 per cent, and excess power needed was bought at 1¼ cents a kilowatt-hour. The plant ran 24 hr. a day, so that fixed charges per kilowatt-hour were less than for one which ran only part time. If the plant had run but 8 hr. a day, the cost per kilowatt-hour for power generated would have increased in the ratio of 4 to 10, the fixed costs being 70 per cent of the total for a 24-hr. load and 84 per cent for an 8-hr. load.

*From a paper before the Providence meeting of the A. S. M. E.

Keeping Boiler Headers and Caps in Good Condition

REFACING OF TUBES AND CAPS IS DONE WITH REVOLVING EMERY CLOTH BY AN ESPECIALLY DESIGNED MACHINE. BY J. B. PETRIE

YEARS AGO it was quite common to see leaky boiler tube caps. In those days they were our greatest enemy. Since then I have learned through different engineering magazines that many engineers still are

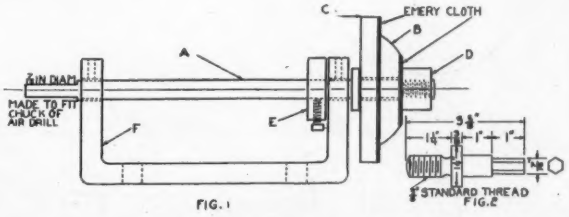


FIG. 1. THIS IS A HOMEMADE MACHINE FOR REFACING BOILER CAPS AND NUTS

FIG. 2. FOR REFACING THE CAP SURFACE ON THE HEADERS, THIS DEVICE IS FITTED TO AN AIR DRILL

confronted with the same trouble and, for their benefit, I shall explain how we have avoided it in our plant here.

Our boiler plant consists of four B. & W. boilers of 478 hp. each, equipped with superheaters, and generating steam at 190-lb. gage pressure with the safety valves set for 200 lb.

When the boilers were erected in 1920, the erecter would not allow emery cloth coarser than No. 1½ to be used in facing headers and caps. This is good enough for new work but, when boilers are fed with hard water until considerable scale is precipitated and from 100 to 200 caps have to be taken off for tube cleaning after a boiler has been steaming from 30 to 40 days, No. 1½ emery cloth is not coarse enough to keep the headers and caps properly faced up. This is essential to keep them tight.

We have been using No. 2½ and sometimes No. 3 and find it economical as well as efficient, one sheet doing twice as much surface as the finer grade.

For the first few weeks after the plant started, early in 1921, all cleaning or refacing was done manually. As shown in Fig. 1, the caps were faced on a homemade device, the base of which was held in a bench vise. After

several turns of a small rope about 7 ft. long were passed around shaft A, a helper took one of the ends in each hand and in a reciprocating manner first right, then left, set the shaft revolving in opposite directions at the end of each stroke.

The tube cap was held against the emery cloth on disk C, being guided by disk B. The face of disk C is provided also with emery cloth which is used to clean the nut face of caps, as well as the nut itself. For holding the emery cloth on the face of disks B and C, the necessity of a round nut was obvious, because it had to revolve in the bore of the regular cap nut without damaging the thread.

The face of the headers was cleaned with the device shown in Fig. 2. A piece of emery cloth and washer B, the same diameter as the header facing of the cap, B and C are plan views of disks B and C in Fig. 1 and could be made out of ⅜-in. or ½-in. plate.

After installing an air compressor for tube cleaning, instead of driving the device shown in Fig. 1 manually, an air drill was utilized. After boring a 1½-in. hole in the bench for the throttle to pass through, the drill lay fairly level and with a U bolt over the chuck end, and one over the back, it was made rigid; all that was necessary to complete the outfit was a duplicate of the part shown in Fig. 2 with ¾ in. more thread, together with the disks and nut shown in Fig. 1. A smaller size of air drill was used to face the headers. With these drills, cleaning was done at one-fifth the previous cost.

After getting all surfaces thoroughly cleaned it is necessary to provide a seal between the header and cap

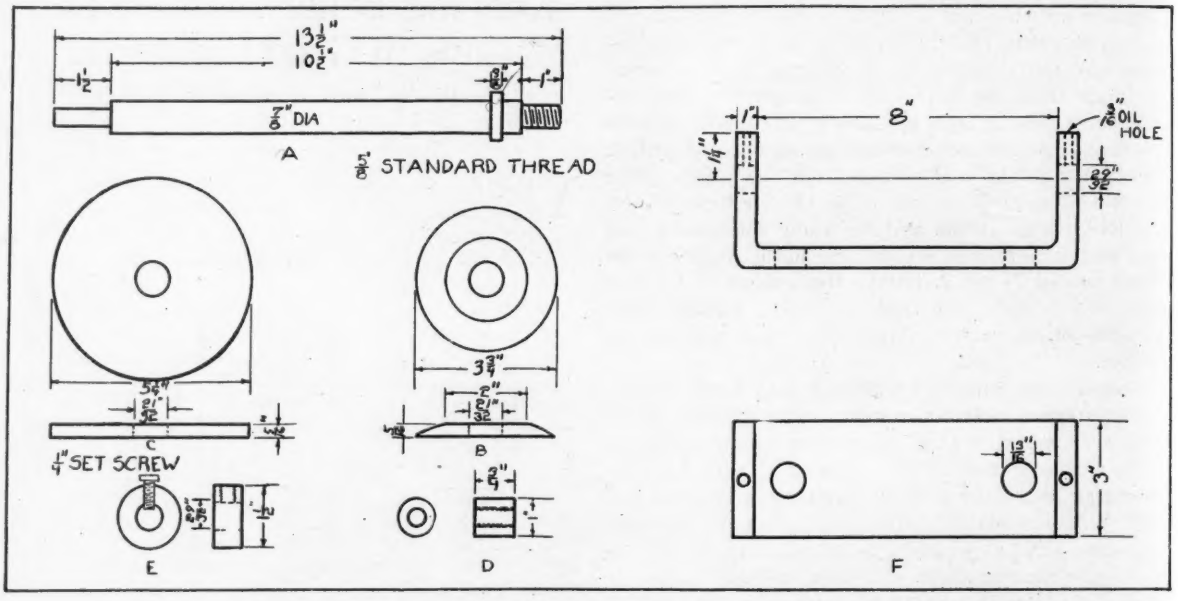


FIG. 3. THIS SHOWS DETAILS OF THE VARIOUS PARTS OF THE MACHINE SHOWN IN FIG. 1

serving as a guide in the hand hole made up with an ordinary ⅝-in. nut, completed this outfit. It may be made of mild steel.

Mud drum handhole faces were cut down from $\frac{1}{16}$ in. to ⅛ in. inside the surface of the drum according to the unevenness of the casting, these requiring a duplicate of disk C in Fig. 3, except of $4\frac{1}{16}$ in. diameter to give it clearance in the counter bore.

Details given in Fig. 3 show that the outfit can be quickly and cheaply made. The supporting frame F could be built almost of any kind of scrap iron and should be bushed with brass for smooth running of shaft A. We had it bushed after converting to power drive and $\frac{13}{16}$-in. holes bored in the base for bolting to an iron bench which was also bolted to the floor.

For efficient operation, the bench should be large enough to contain quite a number of caps to avoid continual stooping to the floor. One man then can chip off scale while passing the caps along to the second man for facing. Shaft A was turned from a piece of mild steel. E is the collar used to adjust the end play of shaft A. As already mentioned, nut D must be round in order to run inside the cap nuts when facing them.

and a mixture of powdered graphite and boiled linseed oil has been found most effective. The proofs of this lie in the fact that during the last 5 yr. we have not taken off a single boiler on account of leaky caps.

The oil should be boiled from 10 to 15 min., the graphite sifted and the oil mixed in the powder until a thin paste is made. This paste should be put on with the fingers to avoid grit of any nature getting on the joint. Some of this paste in a thin film will be left or baked on the surfaces when the caps are taken off.

To remove this film and economize in emery cloth, use No. 3, just skimming the surface without trying to finish, for as many caps as the cloth will do. A new cloth then will make a finished job of that number which seldom reaches above five. Referring again to Fig. 1, the center of the cloth on disk C always can be cut out to fit disk B.

SALES OF BOILERS and mechanical stokers, as reported by 12 manufacturers were for July, 20 fire-tube boilers of 2594 aggregate horsepower, 105 water-tube boilers of 47,540 aggregate horsepower and 125 stokers for 50,494 hp.

Men on Shift Work Should Have Higher Pay

By A. F. Sheehan

NOT THE least of the engineer's troubles when in charge of power plants is the evil of constantly changing personnel in the boiler room. This trouble exists to a greater extent in plants with a continuous load than in plants running only from 7 a.m. to 5 p.m. Where the plant has to run day and night all week, stopping only for a few hours on Sunday while the majority of other plants in the immediate vicinity are running only a day shift, the day and night plant is at a disadvantage in securing the right class of boiler room help unless the pay is higher or some other inducement is given to compensate for the inconveniences.

I have found that the third shift is the most unpopular whether it starts at 11 p.m. or an hour earlier or later. The men suffer from lack of sleep, especially in the summer and dislike this shift even if they come on it only one week out of three. Among the younger men the shift starting in the middle of the afternoon and ending an hour or two before midnight is nearly as unpopular, due to lack of social diversion, but the older men prefer it to the last shift.

In one plant which carried a fireman, fireman's helper and a coal and ash wheeler on each shift the men all had applications in at the superintendent's office for a transfer to the outside labor force as this work meant day work exclusively. I had suggested an increased wage differential to make the night shift more attractive but any suggestion of higher pay met with slight enthusiasm in the office.

In my second year at that plant, during winter months our force was nearly intact but with the first signs of spring, the exodus from the boiler room began. The former year we had no difficulty in finding men even though they were not the type we desired but, due to several local construction jobs starting that year, we were faced with the prospect of running the plant with a reduced force.

Our heaviest load came on about 7:30 a.m. and went off at 4:30 p.m. with a reduction during the noon hour. The night load was lighter but the same number of men were carried on each shift as all fires were cleaned on the night shifts, also the ashes were removed then and tubes blown. We had no steam flow meters to show us the exact load on each shift but the coal tally marked up by each coal passer was a fairly good index of the load on his shift as the same amount of coal was left on the floor at the end of each shift. The afternoon shift used about two-thirds as much coal as the day shift and the night shift slightly less than that. Inasmuch as the fires were cleaned at night, this meant greater coal consumption than the reduced load would call for as the boiler output was anywhere from zero to 25 per cent of normal during the cleaning period. So the night load, under these conditions, was not over half the day load.

For this reason, I proposed the following plan: As the day load was carried by two men who had no extra duties, such as cleaning fires, it followed that one man could carry the reduced night load except for the extra work involved in cleaning fires. Also, the ashes removed at night could be removed during the day and the night coal wheeled in the daytime by the simple process of transferring the man responsible for this work from the night shift to the day shift. Also, the night helper could be transferred to the day shift and the fires he had been cleaning at night could be cleaned early in the day before the load came on.

We first transferred the helper so that he came on at 6 a.m. and cleaned his fires and ashpits. As the coal pile was left low with no coal passer on the night shift, one coal passer started at 6 a.m., both men going off at 2 p.m. This created two day jobs where two night jobs formerly existed and the men were immensely pleased with the arrangement and no extra work was put on the night fireman who was left alone on the night shift. The day shift did not have to meet the heavy load which came on at 7:30 with all dirty fires because at 6 a.m. two fires could be cleaned and, as this man would remain on till 2 p.m., he could clean another fire during the light load at noon.

As we had five boilers on the line that left two fires to be cleaned later in the day. The helper on the afternoon shift was transferred to day work starting at 10 a.m. and going off at 6 p.m. Between 4:30 and 6 p.m. he cleaned the last two dirty fires and, as the load was light from then on, one man per shift handled the boilers without difficulty, having no more to do than formerly. We were short one coal wheeler at that time and decided to try to get along with one man less as common labor was difficult to get at the time.

This is the way the shifts were finally planned: One fireman and helper on at 7 a.m. to 3 p.m., one fireman on from 3 p.m. to 11 p.m. and one fireman on from 11 p.m. to 7 a.m., the former night helper and coal wheeler on at 6 a.m. to 2 p.m. and the former afternoon helper and coal wheeler on at 10 a.m. to 6 p.m. Two fires could be banked at night and the night firemen were given at least two clean fires to start with, while the day shift had to clean all fires in the light load periods occurring at early morning, noon and late afternoon. No objection was raised about the small amount of extra work put on the coal and ash wheelers, due to the dropping of one man from the crew, as they were more enthusiastic about the new schedule of working hours and better co-operation existed among the men than before.

I called to the attention of the management that as the firemen were now the only ones forced to work on night shifts nothing had been done so far towards improving their conditions, the changes made benefiting only the unskilled men. The firemen's rate per hour was only four cents above that paid the helpers and common labor and I have always considered a good fireman to be far ahead of common labor, both in intelligence and the importance of his work. I suggested raising their rate till there was a differential of at least $5 per week above the unskilled men. Even with this increase the total labor cost in the boiler room would not be increased above the former cost, but it was with the greatest difficulty that the management was persuaded to raise the rate of the firemen. But once this was done, there was never any difficulty in retaining our help in the boiler room.

Rapid Progress Made at Gulf Island

By John L. Collins*

ON THE ANDROSCOGGIN River, about 5 mi. upstream from the twin manufacturing cities of Lewiston and Auburn, Me., the Central Maine Power Co. is proceeding rapidly with construction work on its New Gulf Island Station. In spite of unfavorable weather conditions during the early part of the summer, construction has been kept to schedule and installation of the equipment started in July.

Three Allis-Chalmers 112½-r.p.m. vertical water wheels with concrete scroll cases and hydrocone draft tubes will operate under a normal head of 50 ft. Each of the three turbines will develop 9000 hp. and they will be direct connected to three 8000-kv.a., .8-p.f. General Electric generators with 250-v., direct-connected exciters. Generators are connected with the neutral grounded through current transformers for differential relays.

Three-phase, 60-cycle current at 11,000 v. will be generated and stepped up to 33,000 v. for distribution over the five lines utilized to tie this station into the company's present system. Main generator leads are made

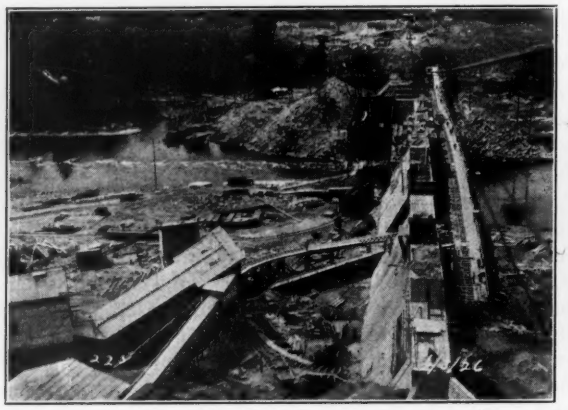


FIG. 1. BIRD'S-EYE VIEW OF DAMSITE AS IT APPEARED DURING THE EARLY PART OF JUNE

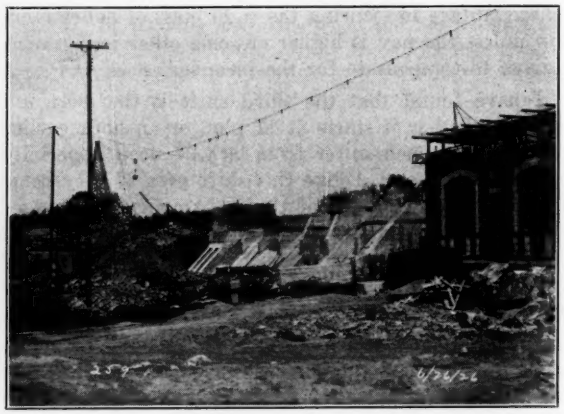


FIG. 2. CONSTRUCTION WORK WAS GREATLY FACILITATED BY THE 15-T. CABLEWAY SPANNING 2000 FT. OF THE DAM

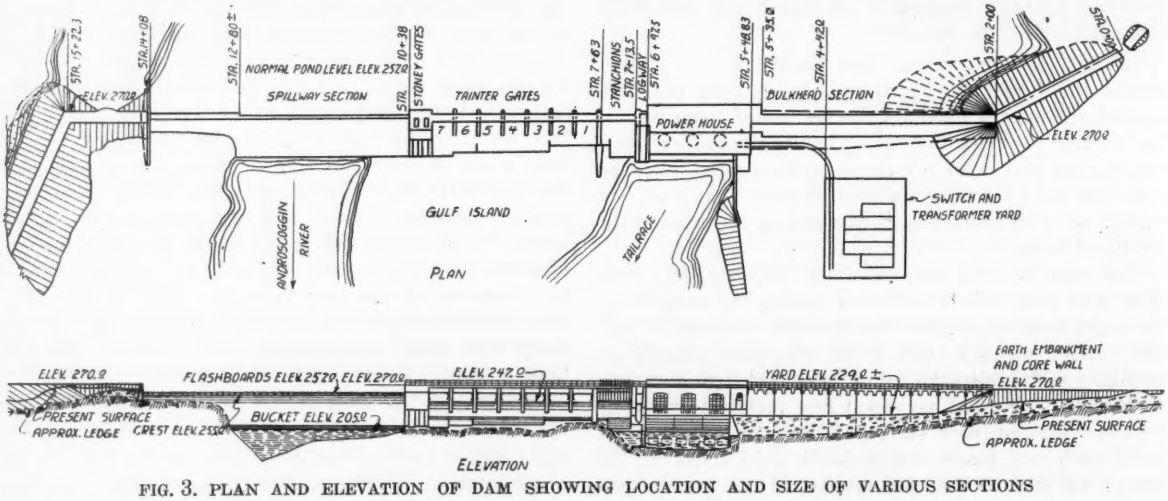


FIG. 3. PLAN AND ELEVATION OF DAM SHOWING LOCATION AND SIZE OF VARIOUS SECTIONS

This project of 27,000 hp. is one of the most prominent of New England's recent hydro-electric developments and will utilize the run off from approximately 2860 sq. mi. of northwestern Maine, an area well controlled by storage facilities, both in and below, the Rangley Lake district. Construction and installation costs will be close to $5,000,000 and the station will add approximately 24,000 kv.a. to the company's present generating capacity. Estimates place the yearly output at 100,000,000 kw-hr.

up of two separate three-conductor cables running through an underground conduit direct to the oil switches and transformers in the outdoor substation. Each generator is provided with a three-phase, 8000-kv.a. transformer and a separate 11,000-v. line. All high tension switching apparatus will be located in the substation and will be remote controlled from a separate panel on the switchboard balcony in the power house.

Construction work on the power house is practically completed. The building of buff brick, 148 by 30 ft., is an integral part of the dam, located over the east fork of the river in order to utilize the natural channel

*Central Maine Power Co.

as a tail-race. The switchboard balcony, or control bay, upstream from and considerably higher than the generator floor, has an unobstructed view of all three units. Blue Vermont marble panels are set in bays so that the face of the panels mount flush with the brick walls on either side. Boards are in three sections: the main control board, the relay board and the station service board, each unit being located at the point most convenient for the operators.

Carrier current telephone communication will be used between this and other stations to insure co-operation with the minimum danger of service interruption. Three shifts of two men each will be required for operation. Efficient use of the available water will be made possible by a 3000-acre storage pond created by the mass concrete dam. This lake, extending upstream about nine miles with a maximum width of about 5000 ft., will be utilized only for immediate storage, the flow into it being controlled from farther upstream.

Taken as a whole with the two earth embankments, the dam is close to 2600 ft. long, although the concrete section, containing approximately 100,000 cu. yd. of concrete, measures but 1326 ft. Size and relative proportions of the various sections are well brought out in the plan and elevation, Fig. 3; the vertical distance from the bottom of the foundation to the highest part of the dam measures 115 ft. Flood capacities of about 160,000 cu. ft. per sec. can be handled by the several waterways, which were designed to allow a liberal leeway over the maximum flood flow of 65,000 cu. ft. as shown by the hydrographic records.

Equipment and materials are brought to the damsite over a standard gage spur track built for this purpose from the main line. Construction is carried on both from a narrow gage track and 15-t. cableway, the latter served by a 300-hp. hoist, is suspended from two 200-ft. towers and spans 2000 ft. of the dam.

Present progress of the work indicates that the project will be completed and the plant operating in January, 1927.

Atmospheric Pressure Affects Ice Machines

ANALYSIS OF DIFFERENCE IN CAPACITY AND POWER CONSUMPTION BETWEEN IDENTICAL MACHINES WITH DIFFERENT BAROMETRIC PRESSURES. BY W. H. MOTZ

AMMONIA COMPRESSORS in ice and refrigerating plants are operated under various atmospheric pressures. These variations of atmospheric pressure are caused by the location of compressors at different heights above sea level and by climatic changes in a given locality. Climatic disturbances in the air cause the barometric readings to vary from 26 to 31 in. of mercury under extreme conditions. The decrease of pressure of the air due to elevations above sea level is approximately:

Altitude above sea level, ft.	0	1000	2000	3000	4000	5000
Atmos. press., lb. per sq. in.	14.7	14.2	13.6	13.1	12.6	12.1

To study the effect of the variation of atmospheric pressure upon the operation of ammonia compressors in ice and refrigerating plants, data will be analyzed from two practically identical compressors, operated under the following conditions.

No. 1 Compressor	
Suction gage pressure	15 lb. per sq. in.
Condenser gage pressure	185 lb. per sq. in.
Atmospheric pressure	13 lb. per sq. in.
Volumetric efficiency	66 per cent
No. 2 Compressor	
Suction gage pressure	15 lb. per sq. in.
Condenser gage pressure	185 lb. per sq. in.
Atmospheric pressure	15 lb. per sq. in.
Volumetric efficiency	68.5 per cent

It is assumed that the liquid ammonia goes to the evaporator at a temperature corresponding to the condensing temperature due to the pressure; that the vapor leaves the evaporator in the dry and saturated state; that there are no losses due to radiation; that the compression of the ammonia vapor is adiabatic.

Using the properties of ammonia as given in U. S. Bureau of Standards circular No. 142, the essential data are calculated as follows:

No. 1 Compressor	
Aboslute suction pressure, lb	28
Absolute condenser pressure, lb	198
Heat content of vapor at 28 lb., B.t.u. per lb	610.7
Heat content of liquid at 198 lb., B.t.u. per lb	150.2
Refrigerating effect, B.t.u. per lb	460.5
Lb. ammonia per min. per ton refr	0.435
Spec. volume of vapor, cu. ft. per lb. at 28 lb. abs.	9.853
Theoretical displacement per ton refr., cu. ft.	4.29
Actual displacement per ton, cu. ft. per min	6.50
Heat content of gas after compression, B.t.u. per lb.	737.4
Theoretical work of compression, B.t.u. per lb.	126.7
Actual indicated hp. per ton refr	1.97
No. 2 Compressor	
Absolute suction pressure, lb	30
Absolute condenser pressure, lb	200
Heat content of vapor at 30 lb., B.t.u. per lb	611.6
Heat content of liquid at 200 lb., B.t.u. per lb.	150.9
Refrigerating effect, B.t.u. per lb	460.7
Lb. ammonia per min. per ton refr	0.434
Spec. volume of vapor at 30 lb	9.236
Theoretical displacement per ton refr., cu. ft.	4.01
Actual displacement per ton refr., cu. ft. per min.	5.85.
Heat of gas after compression, B.t.u. per lb	733.2
Theoretical work of compression, B.t.u. per lb.	121.6
Actual indicated hp. per ton refr	1.82

It is interesting to note from the foregoing that the compressor operating under 13 lb. atmospheric pressure requires a relative displacement of 6.50 cu. ft. per min. per ton of refrigeration, as compared to 5.85 cu. ft. for the compressor operating under an atmospheric pressure of 15 lb. This means that the refrigerating capacity of the first compressor is only 90 per cent of the capacity of the second compressor. The net loss of capacity for the conditions given is, therefore, 10 per cent.

It will be further noted that actual indicated cylin-

der horsepower of the first compressor is 1.97, while the corresponding horsepower for the second compressor is 1.82 per ton of refrigeration. This represents an increase of power requirements of about 8 per cent.

From the ammonia tables it will be observed that the evaporating temperature corresponding to 28 lb. abs. press. is —3.4 deg. F., while the same for 30 lb. abs. press. is —0.57 deg. F., notwithstanding the fact that the suction gage presure for both machines is 15 lb.

The effect of variation of atmospheric pressure upon the operation of ammonia compressor was drawn to the writer's attention through an analysis of the operation of an ammonia compressor, No. 1 referred to above, located at a fairly high altitude in Colorado. The operator of the No. 1 compressor was instructed to maintain a suction of 15 lb. gage with the result that the refrigerating capacity of the machine was about 10 per cent too low and the power consumption per ton was about 8 per cent too high. In order to obtain the same efficiency as produced by the No. 2 compressor, which was operated at sea level, the suction gage pressure should be 17 lb. and the condenser gage pressure should be 187 lb., due to the fact that the atmospheric pressure at No. 1 is only 13 lb.

Cold Storage of Fruits and Vegetables

GOOD RESULTS DEPEND ON ATTENTION TO PILING, AIR CIRCULATION, CORRECT ROOM TEMPERATURE AND OTHER FACTORS. BY J. F. STALEY

AS WE CANNOT regulate the growth of fruits and vegetables to cover all seasons we must store them in such a way that they will be palatable at times when they are out of season, also at times when they will demand a good return on the investment that has been incurred from the time they were planted until they are placed on the market. Today there is in cold storage almost every kind of fruit and vegetable that is grown; cut flowers are also placed in cold storage.

In keeping these products in cold storage warehouses, one of the principal points that has often been overlooked is the admission of fresh air. We know that human beings must have plenty of fresh air, and we now find that all places in which human beings congregate in numbers such as schools, churches, theatres and public buildings, are equipped to supply them with an abundant quantity of fresh air, often treated by air conditioning apparatus. For vegetables and fruits in cold storage it is just as important to supply them with fresh air as it is to supply human beings with it.

PROBLEMS IN STORING EGGS

Let us first consider the problems which arise in the storing of eggs. The best eggs are those which are stored early in the season, when the fowl receives grain and dry food and not much green food. Rooms for egg storage may be of any size, depending on the amount of room available, although it has been proved better economy to have the room large enough for about 30 cars of eggs. These rooms should be well insulated, with a smooth cement plaster ceiling, which should in general be not over 9 ft. high. Egg storage rooms should be well white-washed at least once a year. The rooms should be brought down to a temperature of 36 deg. F. before taking eggs into them.

In piling cases of eggs, the first layer should be piled resting on pieces of 4 by 4-in. timber. These 4 by 4's should be laid on the floor so that the ends of the cases will rest on them. Cases should not be placed nearer the walls than 10 in. Between the next three layers of cases should be placed wooden strips 1 in. by 1 in., the next row should be spaced by 2 by 2-in. strips and then the piling can continue with 1 by 1-in. strips between the cases. A space of at least 12 in. should be left between the top cases and the ceiling. After the room is filled with cases of eggs, the temperature should be lowered gradually about 1 deg. a day until it reaches 30 deg. F. It should be kept there until the eggs are to be withdrawn.

If possible, the temperature should not be allowed to vary more than half a degree at any time. Fresh air should be conducted to the room by a system of ducts near the ceiling and should be conducted out by ducts placed near the floor.

Humidity of the air in the storage room should be measured at least once a day with a wet and dry bulb thermometer. The reading of the wet bulb should in general be from 1 to 1½ deg. lower than that of the dry bulb. In rainy, damp weather the air ducts should be closed and should be opened again on bright, clear days.

BRINE SYSTEM PREFERRED TO DIRECT EXPANSION FOR THIS WORK

Brine system of refrigeration is best suited for cold storage work, as a much more even temperature can be carried with this system than with the direct expansion system. For example, if the storage room becomes too cold and the brine valve is closed, the temperature does not go lower at once, but for a time remains where it was. On the other hand, with the direct expansion system, if the temperature becomes too low and the expansion valve is closed, the temperature is quite likely to drop still further on account of the evaporating of the ammonia remaining in the coils. In such a case it is not good policy to close suction valves. Then too, if the rooms are properly piped with the brine system, a comparatively high temperature brine can be carried. In this way the amount of air circulated is greater, consequently the amount of shrinkage will be less. Where the proper amount of fresh air is maintained the shrinkage is reduced until it is hardly noticeable, so that the product keeps practically the same flavor it had when fresh. When the same air is used over and over again in cold storage rooms, it often becomes musty and naturally the stored product will absorb this flavor.

No other product should be stored in the same room as long as eggs are stored in it, although often when eggs are removed in the early fall the room may then be used for the storage of fruit. If this is done the temperature should be allowed to rise to about 36 deg. F. before taking the fruit into the room.

Apples and grapes may be stored in the same room.

which should be kept at a temperature of 32 deg. F. If apples are stored in boxes the first layer of boxes should be placed on 4 by 4-in. timbers laid on the floor with 1 by 1-in. strips laid between the remaining layers. The strips should be laid just at the end of the boxes so that the weight of the upper boxes will not crush the fruit in the lower ones. When apples are stored in barrels the latter should be stood on end the first layer on 4 by 4's and the remainder with 1 by 1-in. strips between them as described above. Barrels should not be piled over four high and a space of at least 12 in. should be left between them and the wall all around.

Grapes packed in half barrels with sawdust or granulated cork keep much better than those packed in crates. It is a good plan never to pile fruit packed in barrels with the barrels lying down.

Where space is limited pears may also be stored in the same room with apples, but for best results, pears should be kept at a temperature of 31 deg. F., whereas apples are best kept at 32 deg.

Celery Must Be Kept at Just the Right Temperature

Celery is one of our most difficult food products to handle in cold storage. It should be packed in substantial crates placed on 4 by 4's with 2 by 2-in. strips between the layers of crates. Spaces of 10 in. should be left between wall and crates and 14 in. between ceiling and crates. The temperature should be 33 deg. F. At no time should it be allowed to drop below 32½ deg. If apples are to be kept in storage for only two or three months, they may be stored in the same room with celery and carried at a temperature not lower than 32½ deg. provided the apples are firm when they are received.

Storing Potatoes and Onions

Potatoes are now stored extensively in cold storage warehouses. These should be piled in sacks, the piles not over five sacks high and resting on racks at least 4 in. high from the floor. A space of 10 in., as usual, is left between the wall and the sacks. Where space is limited a false floor can be placed above the piles of potatoes and in this way other products can be placed in the same room. Potatoes should be stored at a temperature of 34 deg. F.

Onions are also stored in large quantities and require considerable ventilation. Sacks of onions should either be placed on end, or piled not over four high, allowing an air space on all sides of each pile. As with potatoes the piles should be placed on racks to raise them 4 to 6 in. above the floor. They should be kept at a temperature of 34 deg. Potatoes and onions can be stored in the same room with absolute safety as long as a good circulation of fresh air is maintained in the room.

Oranges, lemons and grape-fruit offer a good short storage product in the mid-summer season. These are to be carried at a temperature of 40 deg. Cut flowers are also kept in cold storage until such time as there is sale for them. They are cut when buds are just opening and on taking them out of cold storage they open readily. Flowers have been kept in cold storage in this manner for as long as four months. In storing flowers the stems should be immersed in water and the temperature kept at 34 deg. F.

Big Sioux Station Operators Feel at Home

Iowa Power Company Conducts a School for Its Employees, Pays for Correspondence Courses and Magazine Subscriptions. By L. A. Cowles

APPROACHING the new Big Sioux Station of the Sioux City Gas and Electric Co., the visitor instantly is impressed by the neat appearance of the grounds and pleasing architecture of the building. Usually hunting out power plants is an easy task—a column of smoke, and you find the source. But this

SIOUX CITY GAS & ELECTRIC CO.

BIG SIOUX STATION—WATER STREET STATION—COURT STREET STATION
COMBINED Monthly OPERATING REPORT
For Month Ending 7A.M. May 1 192 6

PLANT CONDITIONS	BIG SIOUX	WATER STREET	COURT STREET	COMBINED
Station Steam Pressure	350			
Station Steam Temperature	676			
Feedwater Temperature	226			
Vacuum Corrected to 30" Bar.	29.32			
Maximum Load	11,750			
Load Factor Average Load	61.8			
Plant Factor at 80% P. F.	72.7			
TOTAL QUANTITIES				
K. W. H. Generated	5240,000			
K. W. H. Auxiliary	300,000			
K. W. H. Net Generated	4,940,000			
Total Water Evaporated	60,630,000			
Water for Electric Production	60,630,000			
Water to Steam Heat by Meter				
Water Charged to Steam Heat				
Water to Gas Works				
Total Coal Used				
Coal for Electric Production				
Coal to Steam Heat				
Coal to Gas Works				
Coal in Storage				
Days Run in Storage				
K. W. H. to Coal Mills				
OPERATING RESULTS				
Lbs. Water per Lb. Coal	7.61			
Factor of Evaporation	1.1887			
Evaporation from and at 212 deg.	9.03			
Boiler Efficiency	83.4			
Average Boiler Rating	158			
Maximum Boiler Rating	260			
Lbs. Water per Net K. W. H.	12.27			
Lbs. Coal per Net K. W. H.	1.61			
B. T. U. per Lb. Coal	10,495			
B. T. U. per K. W. H.	16,896			
Thermal Efficiency	20.18			
Kind of Coal Burned	IOWA			

CONSIDERING THE POOR QUALITY OF IOWA COAL, THE PRODUCTION OF 1 KW-HR. WITH LESS THAN 17,000 B.T.U., IS AN EXCELLENT RECORD

plant certainly is an exception; there is scarcely a suspicion of smoke from the stack and no spirals of steam.

Remote control switches are outside and, with the exception of one arc, there has been no trouble with this exposed installation. It not only reduced the cost of installation by eliminating the cost of the housing, but materially reduced fire hazards and increased the effectiveness of cooling and ease of expansion.

I was admitted to the Chief's office and allowed an hour of his time. The Chief, Frank Fellwock, is a full grown he-man, pleasant, and a straight from the shoulder square shooter. He is a firm believer in the college man and the development of men in the organization for executive positions. His principal objection, if any, to the average young engineer is his impatience to get ahead. He says it is all right to be ambitious but

much better to spend time profitably in preparation for the boss' job than to waste it in idle wishes. The fact that a man knows his plant does not mean he is prepared to take charge of it, because so few young men have taken the time to get acquainted with themselves and the psychology of handling men always must be acquired slowly.

The Chief insists on one characteristic in particular, and that is honesty. Broad minded executives are concerned these days in placing the right man in the right place, realizing that the interested, enthusiastic worker is much more efficient than the disgruntled misfit. The best change a man can make, if dissatisfied in his work, should be within his present organization. Such a change enables the employe to capitalize the experience gained in the policies of the company and to build up an asset of proved loyalty.

In speaking of the men for whom he has worked, Mr. Fellwock said nobody progresses without help from his fellows or without helping them, stressing the point that a man does not grow alone but with his associates. He also pointed out the fact that the importance of co-ordination and the cultivating of good will for the company and one's fellow workers cannot be overestimated. Your boss is the most important consideration in selecting a job. He may so react upon you as to double or treble your value to him, yourself and the company, or he may so suppress your individuality and cause such a loss of confidence that you cease to develop and advance.

Mr. Fellwock stepped out for a moment and I took advantage of the opportunity to look around the office. On the south wall was an instrument chart rack holding 30 charts, while a table upon which eight trade magazines were neatly stacked and a first aid chart was placed directly back of the Chief's desk. The strict orderliness of everything about the office and the plant, no doubt reflect his mental attitude toward the work.

Company Sends Operators to School

The company supports a school for the employes conducted by graduate student engineers. Classes recite once a week on company time. They also encourage employes in taking correspondence school courses by paying the cost of any course completed and they also pay half the cost of his subscription to any trade magazines, besides allowing him access to the company's library of magazines.

In looking over the plant, an unbounded enthusiasm for their work, associates and the company was found to be the attitude of all the employes throughout the works. This most desirable characteristic in the plant personnel no doubt can be attributed to the company's policy of careful selection of executives and employes, and its interest in the welfare of the personnel. This was evidenced by such conveniences as iced drinking fountains placed conveniently throughout the plant, lockers, dressing rooms and showers.

Only Minor Changes Made Since Erection

Practically no difficulties have been experienced in the operation of this plant, described in the October 15, 1925, issue of Power Plant Engineering, and only a few minor changes have been made. The ash gates are now hydraulically operated, having been changed from air operated, and in the removal of soot from the accumulators, air is now used instead of water which caked the soot.

Waste heat dryers are now removing approximately 50 per cent of the moisture content of the coal as received. Although little dust was noticeable, they are installing a vacuum cleaning system manufactured by Allen & Billmyre Co.

From the mill operator it was learned that little difficulty has been experienced with tramp material in the mills, the coal being passed over a magnetic pulley before being delivered to the raw coal bunkers.

When the installation of a house turbine (1000 kw.) is completed, it will float on the emergency bus as a synchronous condenser, and will handle the house load during any interruption in the service.

In planning this plant, a balance was sought between B.t.u. economy and interest charge and the results obtained have come up to all expectations. This may be shown by the accompanying monthly operating report.

Welded Roof Trusses Show Great Strength in Tests

TESTS of roof trusses made by the engineering laboratory of the Linde Air Products Co., Buffalo, N. Y., have shown interesting results which have an important bearing on truss construction. Preliminary tests on joints of various kinds showed the "plate insert joint" to have marked advantages and this was built into the trusses.

For the comparative test, 40-ft. trusses were used, one being of conventional angle iron sections made by a leading structural shop, a second using like members from the same mill rolling but welded by the Linde Co., a third of similar design but welded up of lighter members, a fourth welded up of tubular sections.

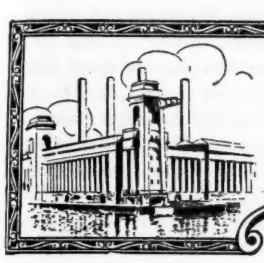
In testing, the upper chord of the truss was given lateral support similar to that which it would have in a building. Platforms were hung from each panel point and loaded with pig iron, the stresses in each member being measured at definite increments of load by means of an extensometer.

Results of the tests were as follows:

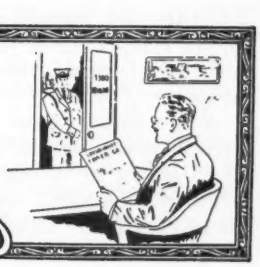
Style	Weight	Total Load at Failure
Riveted Truss	1161 lb.	62,000 lb.
Welded Truss of equal weight.	1150 lb.	72,000 lb.
Welded Truss of lighter weight	1079 lb.	70,000 lb.
Welded Truss of Tubular Sections	916 lb.	63,000 lb.

All trusses failed by buckling of the top chord in compression, no joint showing any signs of distress. Tests were made under observation of engineers from the Pittsburgh Testing Laboratories and in the presence of independent observers and representatives of Government departments.

Investigation by the Bureau of Standards shows that portland cement drain tile is materially increased in strength by placing it in a bath of molten sulphur until it is completely impregnated. The treatment does not prevent ordinary deterioration but decreases absorption of water by the tile.



LETTERS DIRECT FROM THE PLANT



Too Many Engineers Unfit for Job

In the August 1 issue, p. 867, the article by James Ellithorne under the above heading certainly strikes a responsive chord in my own experience. There are too many engineers holding licenses who should not be allowed in a power plant of any size or description.

I am a licensed marine as well as stationary engineer. In the summer seasons I generally do marine work. Recently I shipped as first assistant engineer on a small steamer where the same man serves as both engineer and fireman. Anthracite was hand fired and the quality of water varied over a wide range—sometimes clear, then muddy and at times, Atlantic salt.

It was the hottest boat I ever got into. We were supposed to stand a 6-hr. watch and I stood mine as I was expected to do, but the chief engineer never stood his watch. He was a chum of the deck hand and so that young greenhorn was allowed to stand the chief engineer's watch. It never occurred to him to blow down the water column, and one noon as I went on watch, from force of habit the first thing I did was to blow down the column. When it had settled to normalcy the water level was out of sight in the top of the glass. The embryo engineer was wondering why the engines sounded so queer and the vacuum was 5 in. instead of 20 in. as it should have been.

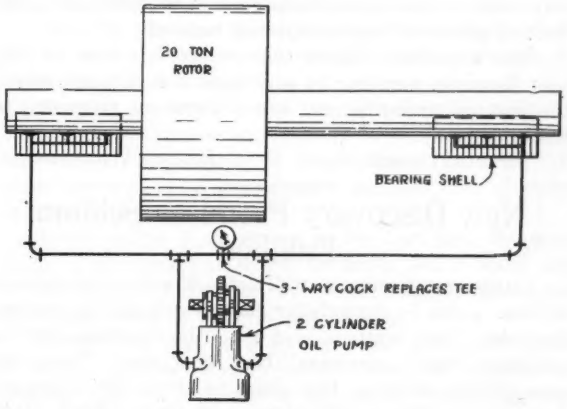
This engine had a riding cutoff valve of the Meyers type and in order to maneuver the boat the cutoff had to be turned off. This was accomplished by a handwheel on the top side near the throttle. One day the chief turned it so fast and used so much strong arm that he split the thread in one of the cutoff blocks and ran the other off the rod. He could not reset the valves nor make any sort of repair although we were fully equipped for such work. He didn't know how and yet he has an engineer's license on condensing lake, bay and sound steam vessels. This chief, like a lot of others, will not allow his men to offer a suggestion and when trouble comes he tries to pass the buck to his men. Yes, there are too many men being given engineers' licenses.

Buffalo, N. Y. S. G. Rogers.

Bearing Lubrication at High Pressure Must Be Controlled

All of us are prone to momentary lapses of memory and at times forget the most commonplace rules of elementary mechanics. The writer must confess to such a lapse in a recent job which he undertook to install.

Large motors and other pieces of equipment having rotating parts weighing many tons are difficult to start from rest unless some provision is made for re-forming the oil film in the bearings, this usually disappearing under the squeezing effect of the shaft pressure while at rest. For this reason it is customary to drill the bottom of the bearing in several places, coning the holes so formed, and to supply oil under high pressure to the bearing through these openings during the starting period. Oil pressure usually is obtained from some sort of a motor driven oil pump and pressures up to and over 750 lb. per sq. in. are quite common.



TO PROVIDE CORRECT PRESSURE FOR EACH BEARING INDEPENDENTLY OF THE OTHER, AND AT THE SAME TIME, PROVIDE MEANS FOR MEASURING THE PRESSURE ON EITHER SIDE AS DESIRED, A 3-WAY COCK MUST CONNECT THE GAGE TO EACH CIRCULATING LINE

An overflow pipe is fitted to each bearing also and a well at the pump usually supplies a reserve of oil. On starting the pump the pressure rises to its highest value, this pressure being just sufficient multiplied by the area over which it acts, to balance the weight resting on the particular bearing involved. As soon as the seal is broken, the pressure drops to a more moderate value and becomes then the bearing pressure at which the bearing was designed to operate.

To make a long story short, it was desired to install a contact making pressure gage in the oil line of the machine under consideration, this being used in conjunction with an automatic motor starting mechanism, to make sure that the oil film had been formed before the starting sequence proceeded. This gage was connected by a common header to the separate oil lines from the two cylinder pump, as shown in the accompanying sketch.

Right here is where the trouble started, for no sooner had the machine been started than the oil began flowing from one bearing well into the other and filling it, started pouring out the filling opening onto the bearing pedestal and filling opening onto the bearing pedestal and floor.

While the flow was not of great volume, still it did not require many minutes to upset completely the oil levels in the two bearings, necessitating the shutting down of the motor.

A few minutes quiet rumination gave the reason for the trouble and with it the obvious solution.

As shown in the sketch, the rotor of the machine, weighing about 20 t., was supported by two bearings, one at each end. This rotor was not equidistant from both bearings but was much closer to the left-hand bearing, although both were of the same size. In consequence, the bearing pressures per square inch of projected area differed widely in the two bottom shells and under running conditions the heavily loaded bearing acted as a most efficient pump, forcing the oil brought up from the well by the rings and around the shaft to the bottom toward the more lightly loaded bearing. Here some of it squeezed out the ends of the shell, the remainder being carried up and out of the top shell.

To remedy this the gage was provided with a three-way cock, as should have been done in the first place, and the two sets of oil lines completely isolated.

This experience shows that it never is wise to connect bearings together by any pipe line through which the bearing pressures can act to force oil from one to the other.

Toronto, Canada. FRANK WILLIAMS.

New Discovery Promises Seldom Fulfilled

COAL MINERS may as well call off any contemplated strikes. John D. Rockefeller may as well sell his pumps, derricks, filling stations, and all. The railroads may as well send their "gondolas" back to Venice. There are some fellows who are just about to knock the props out from under these institutions and they "don't mean contingently."

Two newspaper articles recently published tell, even if they don't show, all about it. First, from up around St. Paul, Minn., comes the news that two brothers, Wm. A. and J. E. Soucy, have a marvelous invention which is to be confided to the waiting public sometime next spring. Why they wait until spring is not divulged but it is presumed to be out of deference to John D., and the Anthracite Aggregation.

However, the Soucy brothers, so it is claimed, have an improved method of "manhandling" electricity by which they can generate steam. The result will be, so they say, heat and power in tremendous volume, with the elimination of coal and oil, and possibly gasoline, thus putting poor old John D. in the hands of a receiver.

One of the brothers is a cotton broker down in Ft. Worth, Texas, and when interviewed he quite modestly stated: "We don't claim our device is a new machine or any radical departure in mechanics or mechanical engineering. It is merely electricity diverted in a manner never before used." From there on the public is left in the dark.

Another, and even more recent discovery is that of a New Orleans man who is soon to tell the world, cockeyed or otherwise, the proper way of using all the pent up energy of nitroglycerin.

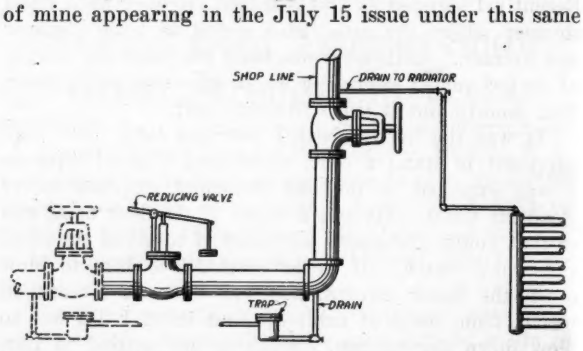
His plan is to feed just the right proportions of nitroglycerin into the combustion chambers of automobiles and similar engines, and by exploding said nitro at proper intervals by means of the electric spark he says he will be able to produce motive power at less than one-third its present cost. One can see at least some good in the latter invention, for if a couple of cars "tanked" up on naughty nitro should run together there need be no ambulances to cart off the victims and no lawyers to litigate. There likely would be nothing left to cart and little left for litigation.

We must not smile at these claims for we are reminded by each inventor that the world smiled, grinned and scoffed at Columbus, Fulton, Watt and several others, but that finally they had the last laugh which is by far the best.

San Antonio, Texas. H. R. MOORE.

Water Hammer Caused By Undrained Pockets

UNDER THE above heading, in the August 15 issue, W. R. Moynan made a suggestion relative to an article of mine appearing in the July 15 issue under this same



THERE IS A VALVE ALREADY IN THE POSITION SHOWN BY THE DOTTED LINES AND A TRAP AHEAD OF THIS VALVE IS NOT NECESSARY SINCE CONDENSATE DRAINS BACK TO THE BOILER

title, which showed me that more details were required than given, to understand the reasons for the changes made.

In the first place, the shop line valve is in another building and on another floor from the reducing valve. This valve is for the use of the watchman at night. By placing it in this building, the watchmen can reach it without going outside through the snow and weather. We regulate our steam consumption closely because it is largely a purchase proposition and as such is continually before our minds.

This shop line is only one of several similar lines, the reducing valve being located in the engine room and reserved for the chief engineer alone. No profane hands are allowed to touch the engine room and boiler room equipment. If I caught anybody changing my regulators without notifying me, I would run him so fast his vest pockets would dip sand.

It so happens that a master valve is just where Mr. Moynan desires to locate one but it is along the engine room ceiling and condensate to the left of the master valve drains back to the boiler room header, so no trap is needed where proposed. This one line is not used in the summer time and the master valve is then closed.

As for radiator traps, all our radiators are trapped. Just before my coming to this plant, 5 yr. ago, an efficiency engineer bought steam traps by the crate, so there are plenty of traps here.

In the proposed arrangement of Mr. Moynan, the trap ahead of the master valve would not eliminate the water pocket. As we all know, valve seats get worn from throttling steam and valves having high pressure behind them occasionally leak from other causes such as bits of scale lodging on the valve seat. Now these leaks would cause condensate to form between the reducing valve and the elbow and this water, lying in the pipe, would make a resounding crash of water-hammer if the master stop valve were opened suddenly and a quantity of high pressure steam allowed to enter the shop line suddenly and pass over the water lying therein. For this reason the trap must be at the elbow and riser, since it is to this point that condensate from the engine room line would collect anyway and it is, therefore, the proper location for the drain to the trap.

It might also be well to explain that the type of water-hammer eliminated in this case was not the velocity-impact type met with in cold water lines. The hazard in this case was caused by high pressure steam suddenly passing over relatively cool water lying along the bottom of the pipe. The water and relatively cool piping absorb heat from the steam causing a large volume of steam to condense and create a partial vacuum. Immediately a rush of more steam will come in to fill up the partial vacuum, resulting in a resounding crash and sometimes breaking heavy steam fittings.

Moline, Ill. ROBERT ALTHAUS.

Careful Boiler Inspection Necessary After Cleaning

IN THE Aug. 1 issue, under the above title, the letter from J. E. Noble seems particularly appropriate since, in my opinion, careful inspection of all boilers after cleaning is the most important single job in the boiler plant.

We might speak of certain jobs being indispensable, such as tending water, firing or soot blowing, but these are routine duties that the respective men must do all the time. They are paid for just this performance and naturally it is done.

But the careful inspection of a boiler after cleaning is a matter for the foreman himself, and usually he need only suit his own whims, as he is not very closely watched by his superior. And the foreman's chief function is that of supervision and inspection.

As Mr. Noble says, boiler cleaning is a mean job, and the class of labor that does this work usually can be expected to shirk if close scrutiny is not maintained. When the plant is taxed to capacity and the boilers are needed, cleaning quickly follows the taking of the boilers off the line, and is done while the boiler is uncomfortably hot. Under these conditions it is human nature to skip half the tubes in turbining, and only half clean the boiler in general.

I know of one case where a college trained young man became steam engineer of a steel plant and was put in charge of the boilers. One of the duties that was allowed to drift was the inspection of the boilers after the boiler cleaners had finished. Nobody demanded rigid inspection and it was neglected. He had not been schooled in personal inspection, and trusted his boiler cleaners implicitly.

In about a year's time, steam became more and more difficult to maintain, tubes were lost one after the other, fuel consumption ran high, and the number of boilers off the line at a time was greater than ever. The engineer figured that he did not have sufficient boiler capacity to carry the load. Finally conditions became so bad that he left the plant.

His successor was an old time boiler man, who knew little theory, but knew how boilers should be cleaned. He found boiler tubes so heavily scaled that one would wonder how water ever passed through the small passages. It was impossible to get the turbine through many of them. Quite a few tubes had to be cut out, and were found to be almost solid with scale. We had several sawed off sections in the office, and a passing salesman asked us if we had poured concrete into the pieces of pipe. He was aghast when told that these were actual tubes from boilers.

The new boss finally got all the tubes cleaned out and the boilers free from accumulation of dirt and debris. Immediately steam pressures went up and were maintained higher than ever, with record plant production. He had several boilers to spare.

Had the previous man carefully inspected the work of his boiler cleaners and insured a thorough job, he would have had easy sailing.

Another important point in boiler cleaning is safety. The work of the boiler cleaner, in addition to being hot and uncomfortable, is dangerous. He must take every precaution to prevent any possible flow of steam into the boiler.

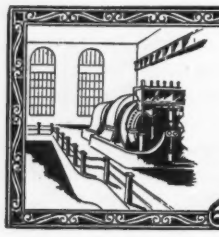
What makes it so serious is the fact that the manholes of the drums in which he works are so small that in the event of a steam or water rush, rapid escape from the boiler is next to impossible.

Not so long ago, on a certain boiler plant, the boiler cleaners neglected to open the drains on the superheater header. The steam valve to the header leaked slightly, so that with the drain valves closed, the superheater tubes gradually filled with hot water and condensed steam. As ill luck would have it, just as the cleaner was under the steam outlet from the drum, turbining the tubes, a puff of steam from the leaky valve blew over a lot of hot water, badly scalding the man. Only the quick work of his companion cleaner (they always worked in pairs) saved his life by getting him out of the drum and procuring medical attention immediately. He had simply forgotten to open the drain valves. This would have prevented any collection of water in the superheaters.

Another source of danger in cleaning boilers is through the blow-down lines. The blow-down valves should be closed and locked when the boiler is down for interior cleaning, so that no steam can back up into the boiler, when the other boilers are blown down. Signs should be placed over the valves indicating that some one is in the boiler, who should be notified to get out of the boiler before any valves are touched.

In discussing boiler inspection after cleaning, it might be well to mention that not only should the boiler interior be carefully examined each time the boiler is down, but the exterior as well. Inspection should be made of the baffles, brickwork, soot-blowers, furnaces, arches, and so on. The entire boiler should be gone over. Such an examination does not require much effort, and might save considerable valuable time, trouble and money.

Pittsburgh, Pa. C. W. STEVENS.



QUESTIONS AND ANSWERS

Proper Condenser Pressures for Ammonia

PLEASE ADVISE the proper temperature to hold the ammonia gas on the discharge side of the compressor. We are under the impression that ammonia has a tendency to break down if the temperature rises above 300 deg. F. Of course, it is possible to keep this temperature down by increasing the expansion on the suction side but we wish to know the proper temperature for the most efficient operation. J. F. P.

A. Before discussing the condenser temperature and pressure, the back pressure will be considered. While no definite rules can be laid down regarding back pressures that should be carried, even under average conditions, the pressures and temperatures given in Table I will be found fairly accurate.

TABLE I—BACK PRESSURES AND TEMPERATURES

Temp. of room, deg. F.	5	10	15	20	28	32	36	40	50	60
Back pressure, lb. gage	7	10	12	15	22	25	27	30	35	40
Temp of ammonia, deg. F.	13	10	5	0	8	12	14	17	22	26

In general, the engineer should endeavor so to manipulate his expansion valves as to carry the highest back pressure possible and still produce sufficient refrigeration in his coldest coolers. A second limit to ammonia feed can be put on the expansion coils without causing liquid ammonia to return to the compressor, causing it to pound and the rod stuffing boxes to leak. It may be mentioned incidentally that the back pressure can be carried materially higher, and the efficiency of the plant materially increased, by keeping the expansion coils free from the insulating effect of ice on the outside and oil on the inside. The coating of ice should be kept as thin as possible at all times and opportunity should be taken to remove oil from the expansion coils at least every two or three seasons, and oftener if much oil is thought to have worked into the system.

When the temperatures get too low, it is better to slow down the machine rather than to reduce the refrigerating effect of the system by closing down expansion valves, reducing the back pressure and literally throwing away power because the refrigeration is not needed. The full importance of this truth seldom is recognized by either the supervising or operating engineer, and generally they do not strive for the last pound of increased back pressure half as diligently as for the last inch of vacuum in the steam condensers, although the former pressure is of far more importance than the latter in its effect on the general efficiency of the plant.

Just as the back pressures have to be reduced in order to reduce the boiling point of the refrigerating medium when low temperatures are required, the condenser pressure always rises sufficiently to raise the boiling point of the medium when the temperature of the cooling water is raised. Table II gives the approximate condenser pressure that should result from the use of different quantities of cooling water of different temperatures on condensers of average proportions.

In every event the condenser pressure should be kept as low as possible and the back pressure as high as the temperatures to be produced will permit, narrow limits between such pressures being as important to the efficiency of a refrigerating system as wide ones are to that of a steam engine, in which the economy increases with the range between boiler pressure and condenser pressure.

TABLE II—CONDENSER PRESSURES AND TEMPERATURES

1 gal. per min. per ton per 24 hr.							
Temp. of cooling water, deg. F.	60	65	70	75	80	85	90
Condenser pressure, lb. gage	183	200	220	235	255	280	300
Temp. of condensed liquid ammonia, deg. F..	95	100	105	110	115	120	125
2 gal. per min. per ton per 24 hr.							
Condenser pressure, lb. gage	130	153	168	183	200	220	235
Temp. of condensed liquid ammonia, deg. F..	77	85	90	93	100	105	110
3 gal. per min. per ton per 24 hr.							
Condenser pressure, lb. gage	125	140	155	170	185	200	215
Temp. of condensed liquid ammonia, deg. F..	75	85	90	93	95	100	105

So far as we know, ammonia is not affected in any way at a temperature of 300 deg. F. for, in ordinary practice, with a condenser pressure of 200 lb. abs., when the temperature of the saturated vapor is 96 deg. F., the ammonia tables show superheated vapor up to 300 deg. of superheat which would give a temperature of 396 deg. F. Higher pressures will give even higher temperatures.

Weight of Ashpit Refuse Unnecessary for Carbon Loss

WHAT IS the correct method of calculating the loss due to carbon in the ashpit refuse? C. B. D.

A. There are two recognized formulas for this calculation, depending on whether the refuse in the ashpit has been weighed or not. In most cases, however, test engineers do not need to bother with weighing the refuse but should obtain an accurate sample.

In this instance the sample of ash and refuse is carefully analyzed and the amount of combustible matter calculated to a dry basis. This is usually considered as pure carbon with a heat value of 14,600 B.t.u. From

a proximate analysis of the coal the amount of true ash in the original coal fired, is calculated to a dry basis. Then the loss in B.t.u. is calculated by the formula:

$$\frac{A \times C}{1.0 - C} \times 14{,}600 = \text{loss in B.t.u.}$$

Where A = per cent true ash in coal, dry basis
C = per cent carbon (combustible matter) in refuse, dry basis.

A second method involves both the weighing of the refuse and its analysis for combustible matter but it is not nor never can be as accurate as the first method. Yet we find a great many engineers carefully weighing the refuse after an evaporation test. Not all the ash in the coal ever can be recovered since part of it is carried through the setting and usually the ashpit is not thoroughly cleaned. For figuring the loss in this manner the formula is:

$C \times R \times 14{,}600 =$ Loss in B.t.u.

Where C = per cent carbon in refuse and R = weight of dry refuse in per cent of dry coal.

In most cases when conducting an evaporation test, determination of the ashpit loss is for the purpose of forming a heat balance. This means primarily that an analysis of the coal must be supplied and it is, therefore, entirely unnecessary to weigh the refuse in the ashpit. At best, it is a hot, dirty job.

As an example of the discrepancy between the two methods and to show how loss of fly ash causes the second method to give a lower figure of loss, let us take the following typical example.

Analysis of the coal gives 15.05 per cent ash, dry basis. In the ashpit refuse 30 per cent carbon, dry basis, was found, and the weight of dry refuse was 21 per cent of the dry coal. By the first method we obtain:

$$\frac{30 \times 0.1505}{1.0 - 0.30} \times 14{,}600 = 942 \text{ B.t.u. loss.}$$

By the second formula:

$30 \times 0.21 \times 14{,}600 = 920$ B.t.u. loss.

Electric Elevator Brakes Must Synchronize with the Motor

IN ELECTRIC elevator practice, what is meant by dynamic brakes and why are mechanical brakes not used? S. K.

A. Dynamic brakes, which can only be applied to installations in which direct-current motors are employed, depend upon the fact that when the current supplied to a d.c. motor, that is running at or about full speed, is switched off, the armature continues to rotate for an appreciable period of time due to the kinetic energy stored in the moving parts. Provided the field is excited, current will flow through any circuit that is connected to the armature terminals, and if this circuit takes the form of a resistance frame, the energy stored in the moving parts will be dissipated in the form of heat. Obviously, under these circumstances the retarding effect can be given any desired value, merely by adjusting the resistance that is placed in circuit.

Mechanical brakes are not used in elevators, due to their sluggishness of operation and their inability to synchronism with the motive power of the elevator. Magnetic brakes are now universally used on all makes of elevators.

On practically all makes of single and tandem worm gear machines, the coupling between the motor and the worm shaft forms the drum on which the braking effort is applied, but in the gearless traction type a special brake wheel that may form part of the vee sheave, is directly mounted on the armature shaft.

Although the design may vary, the function remains the same, i.e., rapidly to absorb the momentum or the kinetic energy stored in the moving parts so that smooth and accurate landing stops may be made from comparatively high car speeds, with the minimum loss of time.

The brake shoes, usually two in number and semi-circular in shape, are faced with woven asbestos or other special brake linings, and are held up to the drum or wheel by means of powerful springs and levers. The levers are coupled to the armature of a powerful electric magnet or to the plunger of a solenoid, the coils of which are so connected that the brake is released immediately current is switched on to the motor. Conversely, a failure of power always stops the lift and applies the brakes automatically.

Preferably, the two halves of the brake shoes should be entirely independent of each other, so that either part is a complete brake in itself, and will be effective on the failure of the other half.

Whatever type of brake is employed, it should be designed for easy and accurate adjustment, so that wear in the shoe linings can be taken up from time to time and satisfactory operation insured.

Means should always be provided for releasing the brake in the event of failure of the motor or the supply current, so that the crank handle can be applied to the motor shaft and the car, if of reasonable size, may be wound by hand to the nearest floor level.

With direct-current supply the problem of satisfactory design is relatively simple, but on alternating current systems it becomes complicated, due to the difficulties encountered in designing a satisfactory magnet. Various types of magnets are being employed, such as single-phase long stroke, polyphase long stroke, polyphase short stroke, and constant stroke.

One of the greatest difficulties experienced in producing a satisfactory a.c. brake is noiseless operation. They are liable to slam when closing and, unless the laminated parts are perfectly surfaced and perfectly alined, they will hum after closure. On some types dash pots are used and certain makers immerse the entire magnet in oil to deaden the noise.

World's Largest Boiler and Furnace

WHAT IS the largest size boiler and furnace ever built and where is it located? A. C. T.

A. The world's largest boiler is installed at Pittsburgh in the Cecil plant of the Allegheny County Steam Heating Co. It is rated at almost 3300 hp., having 32,700 sq. ft. of heating surface.

This boiler, however, does not have the largest furnace as the combustion space provided is only 19,350 cu. ft., whereas at the Avon station of the Cleveland Electric Illuminating Co. the furnace volume for each of the new boilers is 30,600 cu. ft. The boilers are almost as large as the one at Pittsburgh, each having 31,392 sq. ft. of total heating surface.

EDITORIAL COMMENT

Power Available, Wealth and Wages

In his presidential address before the Institution of Engineers of Australia, G. A. Julius made interesting comparison of the use of power with a country's wealth and the wages paid to its workers. Data given were for the United States and Australia and showed a striking consistency of cause and effect.

From 1850 up to 1900, wealth per capita in the United States increased at a steady rate of about $17 a year. Records of horsepower per employe start in 1870 and show a steady growth almost parallel to that of wealth per capita up to 1890, when there was a sharp rise in power use, the yearly increase in horsepower per employe jumping from 0.01 hp. to 0.073 hp. In 1890 each worker had about 1.35 hp. available and in 1920 about 3.6 hp.

Increase in wealth per capita started its rapid rise some 10 yr. later in 1900 but, from that time, rose nearly parallel with the increase in power available, increasing about $90 a year.

In comparing the increase of wages per employe, the change is not so abrupt but, starting in 1909, there was a rapid increase in wages, which turned sharply upward from 1914 to 1919, then came back to the rate of increase which existed from 1909 to 1914.

Similar relations were shown to exist in the progress of Australian industries, although increase in power per worker; also in wages per employe, in output per worker and in per capita wealth have been greater in the United States than in Australia. From the figures which Mr. Julius gave, it would seem that, on the average, the United States worker is increasing his output more rapidly as more power is made available for his use but the Australian worker, although increasing his output, has not, of late years, increased it so rapidly as the power furnished him has increased. But, in both countries, the output per worker, his wealth and the return which he receives for his labor have risen markedly with the increase of power available to him and the process shows a trend of even more rapid acceleration.

Lumber Production Not Decreasing

Without any such intention, a short article in the July 15 issue of Power Plant Engineering in the Condensate section, which was contributed by an outside writer, seems to have brought fear of misapprehension on the part of our readers as to the condition of the lumber industry. We hasten to correct any wrong impression which may have been made by the article.

It would seem that the title of that article, Lumber Singing Its Swan Song, was altogether too conclusive, as a number of our friends in the lumber industry assure us, not only that the lumber industry is very much alive, but that it is showing a healthy growth and that the supply of timber is being conserved by modern methods of harvesting and by government campaigns for reforestation in all the timber producing sections of the country. Figures are furnished by The Timberman of Portland, Oregon, showing that, while there has been more or less yearly fluctuation in lumber production as there is in all commodities, during the year 1924, there was nearly 36,000,000,000 board feet produced which is only about 8,000,000,000 ft. less than the maximum year of 1909, before concrete and steel construction had achieved its present popularity. From the same publication, we have the statement that 85 per cent of all buildings in the U. S. are of frame construction and a large part of the rest are about 45 per cent lumber. The statement is further made that every state that has ever produced lumber is producing it today, that no complete survey of the amount of standing timber has been or can be made, and that there is no danger that lumber values will rise above competitive levels.

It is admitted that the lumber consumption per capita is decreasing but the total production of lumber is being well maintained and with the measures now under way there will never be a scarcity of supply.

Unquestionably The Timberman is in better position to know the facts in its own field than is Power Plant Engineering, and we are glad to receive and to pass on to our readers this information. Obviously, in the construction of power plants, it is desirable to use the most permanent and fire-resisting materials that can be obtained and we feel that steel, brick and concrete are the best materials for building power plants. Obviously, also, in many places nothing can take the place of lumber and it is good to know that we may be assured of a continuing supply for those purposes and that the lumber industry is prepared to supply what is sure to be an increasing demand as the population of the country increases.

Cooperation in Engineering Developments

While the larger and more important manufacturers of power plant equipment no longer try to maintain an air of secrecy regarding their equipment, some of the smaller ones persist in bolstering up the wall of isolation, presumably to keep competitors from duplicating their equipment. As usual the most elaborate precautions are taken by those who have nothing to lose, those who live largely on what they get from others. Their real fear is not that they will lose valuable information but that the weakness of their organization will be exposed.

During development there is good and sufficient reason for not broadcasting information as each machine, or process, requires a certain amount of actual service under operating conditions to perfect details. During

such trials, rumors grow and one or two minor mishaps at this stage can develop into serious adverse propaganda, when active sales work is started. Again, certain processes require a certain amount of secrecy, although manufacturers realize that employes will talk and that competitors making a genuine effort to obtain information can do so in spite of precautions.

Engineers, however, are seldom interested in details; they want the general development or design, a mere outline which can be detailed to fit their specific conditions. Problems are much the same in all parts of the country and a dozen different interests may be working on the same problem or experiment. Important progress made by one and announced enables the other eleven to pick up and continue the work so that there are always a dozen working at about the same point of the same problem, instead of a dozen individuals each of whom must discover each step for himself.

Engineering is rapidly approaching the stage where, like medicine and surgery, discoveries are not individual but belong to the profession. It is certain that, without such frank discussion of problems and results, power generation would be far from its present state of development. Increased cooperation with engineering periodicals and societies has been instrumental in spreading information and bringing about the realization that business prosperity depends not alone on individual effort but on the prosperity of the entire country and the prosperity of the country, in turn, depends upon cooperation of all industries.

Off Duty

To the student of mass psychology an interesting thing about the American public or that of any civilized country is its extreme gullibility in the matter of pseudo-scientific hokum. This, of course, is the inevitable accompaniment of a scientific age, the understanding of which is far above the average level of mental capacity.

It is a recognized fact that the public likes to be fooled but, as has been pointed out in this column on a previous occasion, today, it demands that the technique employed have a scientific twang. If radio or electricity can be brought into the story, so much the better.

It is no longer possible to sell hair tonic merely on the strength of the medicine man's orations or on its inherent goodness. That may have served in times past but, today, a more progressive method is needed. Today, to sell hair tonic it is necessary to run a series of full page advertisements, first, showing a diagram or a retouched microphotograph of a hair and a cross-section of the scalp, explaining how the upward electrical pull of diverse electric light and power wires, under which we walk all day, tends to dislodge the hairs from their sockets. The hair, it must be shown, always carries a negative electric charge, due to the prevalent use of rubber combs. It is the electrical attraction between the positively charged overhead wires and the negatively charged hair that is responsible for so much baldness among civilized people. At this point it is well to bring out that the aborigines of Africa and Tasmania are never bald.

Having shown the cause of baldness in this manner, the next step is to show by diagram how the positively charged molecules of "Volthair," the wonder electro-positive hair restorer, work their way in between the particles of negative electricity on the hair, effecting complete neutralization. Finally, it is only necessary to explain that electrically neutral hair is unaffected by external charges and, therefore, cannot be pulled out by overhead wires. From then on it will be easy sailing and the orders will commence to pour in. A picture of the great laboratory filled with whirring generators and white-robed scientists looking at fleas through microscopes is always a valuable adjunct. The time required by the scientists in this laboratory to make the discovery should never be put less than 20 yr.

We could further illustrate this technique by showing how a tooth paste ad should be written or how to "put across" a new species of shoe blackening or a face powder but we would do so at the risk of repetition. In such cases, as in the one shown, would be presented, first, a simple explanation (in terms that every ignoramus can understand) of tooth decay, or shoe deterioration, or complexion trouble, after which the electrical or chemical action of the remedy would be described. The picture of the laboratory, in which 20 yr. of research was expended, would be included in each case.

It is this method that has been so successful in launching various pseudo-scientific systems for the treatment of disease. The Abrams Electronic Reaction theory and the various non-medical and non-surgical methods of treatment of disease in use today are excellent examples. The actual mechanism of the electron and its true relation to matter and electricity is, of course, a matter far above the average human being's capacity of understanding but Dr. Abrams, who was more a psychologist than physician, did not let that fact deter him, in utilizing the electron to exploit the public. He simplified electron matters so that any dolt could grasp them.

This broadcasting of pseudo-scientific hokum, however, is not confined to the selling of tooth pastes or hair tonics or systems for the cure of disease. It extends to all fields and even engineering is not free from it. The method is successful wherever it is used.

The human being is a curious animal—he is possessed of an instinctive desire to know the why of things. Before the great advance in science, the average person had no difficulty in keeping abreast of ordinary learning but, as civilization advanced and science gained headway, the masses could no longer keep up and, today, the fields of specialized knowledge are so far above the average mental level that no power on earth can give the masses more than an idea of what it is all about. The inferiority complex resulting from this condition is responsible for the success of the pseudo-scientific theories we have been discussing.

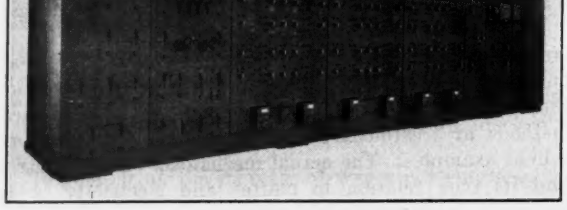
These theories, filled with high sounding, meaningless scientific jargon, are made purposely simple so that the masses, at whom they are directed, elated at finding something scientific which is within their range of understanding, swallow them, line, hook and sinker.

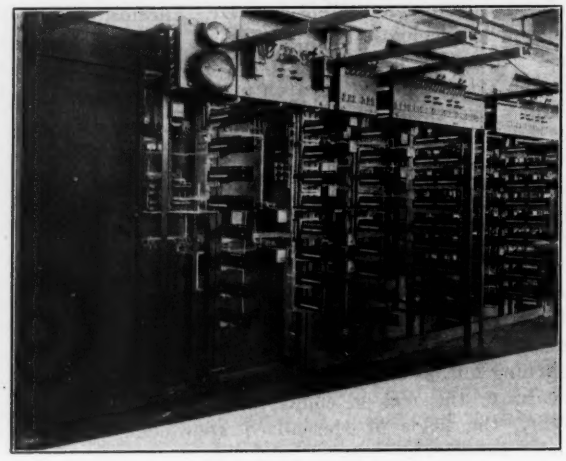
SUCCESS SELDOM is with the unprepared. The successful man is such because he has prepared himself and proven his worth at critical turns in the road. He has paid the price and is therefore entitled to suitable wages. Don't covet the wages if you think the cost too high.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Steel Switchboard for Brooklyn Edison

IN THE ACCOMPANYING illustration is shown a steel panel switchboard which was built by the General Electric Company for installation in the Johnson Street substation of the Brooklyn Edison Company.





STEEL PANEL SWITCHBOARD FOR THE JOHNSON STREET SUBSTATION OF THE BROOKLYN EDISON CO.
Upper view. Front view of board showing meters and control switches
Lower view. Back of board showing arrangement of terminal blocks.

It will control four incoming 26,400-v. high tension circuits and 24 outgoing 4560-v. feeder circuits.

The board was fabricated and wired complete in unit panels before shipment from the factory. Installation in the substation will consist merely of setting the board in place and connecting it to the control cables brought up to the terminal board from the ducts in the substation floor.

Of particular interest is the terminal block arrangement. As there are from six to seven hundred control leads to be connected to each panel, it is necessary to utilize an unusual arrangement. It will be seen by referring to the illustrations that the terminal blocks are mounted on racks at right angles to the board. The control leads are run between the adjacent rows of terminal blocks, thus simplifying the back-of-board arrangement. The upper slot in the plates supporting the terminal blocks is used for bolting and securing the control leads.

Continuous Maintenance for Furnace Walls

FOR THE maintenance of brick or monolithic furnace walls and arches, a new refractory Plibrico stucco has been devised to be applied to the wall or arch as often as the boiler comes off the line, thus replacing any part of the furnace wall that has been eaten away during the last service period.

THE CONTINUOUS MAINTENANCE STUCCO IS APPLIED IN THIN LAYERS WITH AN ORDINARY TROWEL

In the illustration is shown the method of applying this stucco with a trowel in thin coats, several coats being necessary at times. If a single coat of too great thickness is applied, it will not adhere to the furnace wall.

This Plibrico stucco, which is manufactured by the Plibrico Jointless Firebrick Co., Chicago, can be used only where very high furnace temperatures are obtained and, before attempting its use, it is well to have the conditions inspected by one of the company's engineers, who will determine whether or not the operating conditions are such as to make the use of this method

of continuous maintenance possible. Records show that, in one plant with a 500-hp. boiler, operating continuously at 185 per cent of rating, the furnace wall was in good shape after 12 mo. maintenance with the stucco, while previous to the adoption of this method a life of more than 14 weeks was rare.

Metallic Pump Packing

IN ITS new Style 112 John Crane packing, the Crane Packing Co. offers a convenient method for filling stuffing boxes on pump shafts and rods. The new material is made of ribbons of babbit foil wound over a fabric core, giving a round packing ⅛ in. diam. This can be wound on the shaft or rod in one or two layers and forced home by the gland until it becomes a compact, resilient unit, formed to the shape of the stuffing box. Thus only one size of packing is to be carried in stock and other advantages claimed are low friction, long life and freedom from wear on shaft or rod.

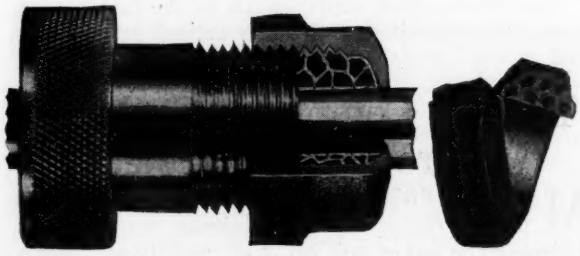


FIG. 1. STYLE 112 CRANE PACKING AS USED IN STUFFING BOX ON PUMP SHAFT
FIG. 2. STRANDS COMPRESS INTO A SINGLE UNIT RING

This form of John Crane packing has been found adapted for oil, water, and gasoline pumps and as gasket material for sealing joints running in grease, as it does not absorb oil or grease yet gives a metal to metal joint.

New Control Equipment for Synchronous Motors

FOR USE in connection with 2300-v. synchronous motors, a completely self-contained, oil-immersed automatic starter has been developed by the Electric Controller & Manufacturing Co., Cleveland, Ohio. This is built for across-the-line starting of slow-speed motors and for reduced voltage starting of the higher-speed motors.

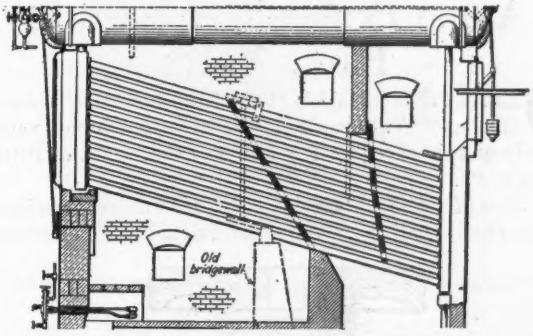
In each case the operator simply pushes a button to start the motor and as the motor approaches synchronous speed, the field excitation is automatically applied. The reduced voltage starter consists of a welded boiler-plate tank which contains an automatic double-throw switching mechanism, a power transformer for providing starting voltage, potential transformers for providing 220 v. for the master switch operating current and the current limit transition relay, which connects the motor to full voltage when it has been accelerated to approximately 85 per cent of synchronous speed.

On the outside of the tank there is a dustproof steel cabinet which encloses a field switching mechanism, field discharge resistor, timing relay and d.c. field ammeter. This cabinet may also contain an automatic starter for operating a magnetic clutch. The full voltage starter is of similar construction except that the starting auto-transformers are omitted.

Monolithic Baffles for Converted Furnaces

IN CHANGING from one type of fuel to another, considerable difficulty has been met in many plants to construct baffles which are suitable for the new fuel. This problem has been successfully met by the Monolithic baffles, built by the Quigley Furnace Specialties Co. They are made in one piece without joints, the materials used being a mixture of crushed old fire brick and Hytempite tamped in place against a rigid wooden lattice work form. The form is burned off when the boiler is brought into service.

In the accompanying illustration are shown the changes made in the baffle location when the furnace of a B. & W. boiler at the U. S. Army base was reconstructed from a coal-burning to an oil-burning installation. The bridge wall was moved back 3 ft. 6 in. so as to give 11 ft. in the clear to the front wall. The front vertical baffle and the inclined rear baffle were replaced by Monolithic baffles.



FURNACE CHANGED FROM COAL TO OIL-BURNING

No metal is used in the construction of these baffles so that there is no necessity for replacing flame plates. Tubes can be withdrawn and replaced without injuring the baffles, and bent or blistered tubes are taken out by breaking away a small section of the baffle around the tube.

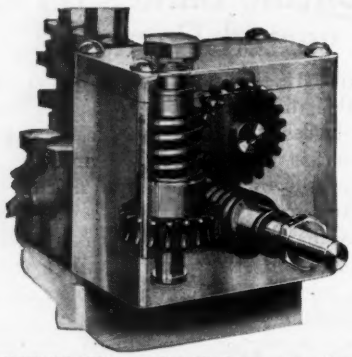
New Small Speed Reducer

DURING THE PROCESS of developing motor-driven lubricators, the Hills-McCanna Co., Chicago, Ill., also worked out a most interesting small-sized speed reducer, which it is now placing on the market. It was found that, for these lubricators, speed reducers giving an 80 to 1 reduction were the highest reductions that could be purchased from stock. These were single reduction units and had the further disadvantage of being large in size, in some cases the reducers being larger than the lubricators they were used on.

Accordingly, the company proceeded to design a reducer of its own and finally produced a unit as shown in

the figure, enclosed in a space only 4 in. by 4 in. by 2½ in. This will give single reductions of 20 to 1 and 30 to 1 and with a double combination of worms and gears, reductions of 50 to 1, 100 to 1, 200 to 1 and 400 to 1.

Standard hardened steel worms are used, running against bronze worm gears, the whole mechanism running in a grease-packed, dust-proof case, provided with stuffing boxes to retain the grease. The shaft projecting at the lower right hand of the cut is ½ in. in diameter for connecting to the motor through a flexible coupling or for belt drive. This speed reducer is designed for motors up to ½ hp.

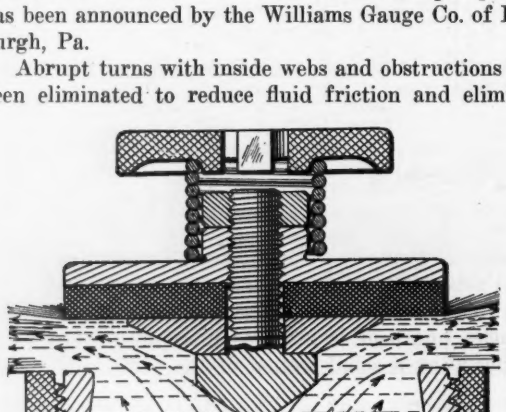


DOUBLE REDUCTION GEAR, ENCLOSED IN CASE ONLY 4 IN. BY 4 IN. BY 2½ IN., GIVES REDUCTIONS UP TO 400 TO 1

Axiflo Principle Applied to Pump Valve

DEPARTING SOMEWHAT from orthodox design, the new Williams-Bullen stream line pump valve has been announced by the Williams Gauge Co. of Pittsburgh, Pa.

Abrupt turns with inside webs and obstructions have been eliminated to reduce fluid friction and eliminate shocks. Tobin bronze is used for the studs and the valve body cast from bronze. For ordinary service, valve discs of Wigaco are furnished but these can be made of any other material necessary to meet specific pumping problems.



CROSS SECTION OF VALVE SHOWING CONSTRUCTION OF VALVE AND DIRECTION OF FLOW

Long Beach Station Has Largest Turbo-Generator in West

SOUTHERN CALIFORNIA EDISON CO. has started in operation the largest steam-turbine generator in service west of the Rocky Mountains, a General Electric 50,000-kw. unit. When this unit was placed in operation in the middle of July, the operating capacity of the Long Beach station of the company, near Los Angeles, was brought to more than 300,000 hp., making the station the largest steam generating plant west of the Mississippi River. The record for size in the west was previously held by the two 35,000-kw. G. E. turbine generators, also in the Long Beach station.

Arrangements for the addition of the third unit were made in October, 1925. The installation includes a main generator rated at 50,000 kw., with a 2800-kw. service generator on the same shaft. It is rated 50 cycles, 1500 r.p.m., 20 stages, 11,000 v., 350 lb. pressure, and 90 per cent power factor.

The boilers which supply steam to the turbines are designed for operation with either natural gas or oil as fuel.

Tacoma Completes Cushman Hydro-Electric Project

MANY INTERESTING FEATURES, some of them unique, characterize the Cushman power project, hydro-electric power unit No. 2 of the City of Tacoma, the initial power unit of which is now virtually completed.

Lake Cushman, from which the project takes its name, is located at the foot of the Olympic mountains, near Hood Canal, the latter the long arm of Puget Sound. The lake is, or was, merely a widening out of the Skokomish River, caused by a natural obstruction in the shape of two giant outcroppings of rock and in the gorge thus formed a constant angle arch dam 265 ft. in height was constructed. This created the new Lake Cushman, a storage basin eight miles long and a mile wide, with a capacity of 450,000 acre feet.

Immediately below this dam, a hydro-electric power plant has been constructed and in it installed equipment which develops 55,000 hp. The principal machinery items are two 27,500-hp. Allis-Chalmers vertical turbines, two generators, and transformers for stepping up the voltage from the power house to the transmission line.

Power is transmitted over dual transmission lines at 110,000 v. from the plant to the substation at Tacoma, a distance of 44 mi. This delivery involves what is said to be the longest single span electric crossing in the world. It passes over the Narrows, an arm of Puget Sound adjacent to Tacoma, where the channel is 4800 ft. wide. The distance between the supporting towers is 6241 ft. Six plow steel 1¼-in. cables are used for this crossing, supported on towers rising 316 ft. above ground and 646 ft. above the water at mean low tide.

This use of steel cables is a radical departure in electrical engineering. The Narrows being a navigable body of water, the War Department required that a conductor clearance of 200 ft. above water be maintained. The Washington State laws governing electri-

cal construction demanded that the crossing be capable of withstanding a theoretical strain imposed by a 70-mi. wind with cables coated with ½ in. of ice at zero temperature and that under such conditions they shall have a safety factor on the ultimate strength of the conductor of not less than two.

The inherent objection to steel cable as a conductor arises because of the high electrical losses and resultant heating, seriously impairing its strength if the cable's temperature is permitted to exceed that at which the annealing of high-strength steel begins. Together, the City of Tacoma and the John Roebling's Sons Co. conducted a series of experiments and proved that the type of cable selected would withstand operating conditions to be imposed by the transmission of the full load over any three of the cables. As normally all six would be used, a sufficient safety factor was present.

New York Power Show Will Be Expanded

DURING the coming National Exposition of Power and Mechanical Engineering at New York in the Grand Central Palace, beginning December 6, four floors will be filled with important exhibits of interest to engineers and manufacturers. The exposition, which is in its fifth year, will have the usual showing of devices for economical generation of power and heat but will also include heating and ventilating apparatus, refrigerating machinery, transmission equipment, material handling equipment and machine tools of all types.

One important section will be that of welding apparatus where ten leading manufacturers will display their newest devices. The welding of structural members for buildings instead of riveting is increasing rapidly and new uses are constantly being found in joining and cutting metals quickly and cheaply.

In the section devoted to mechanical transmission equipment, 60 manufacturers will show the latest developments designed to insure proper lubrication, to avoid worn bearings, loose belts and other faults which result in large losses of power.

The exposition will be held under the management of the International Exposition Co., Charles F. Roth and Fred W. Payne, managers, with offices in Grand Central Palace, New York City.

Polyphase Watthour Meter Indicator Lamp

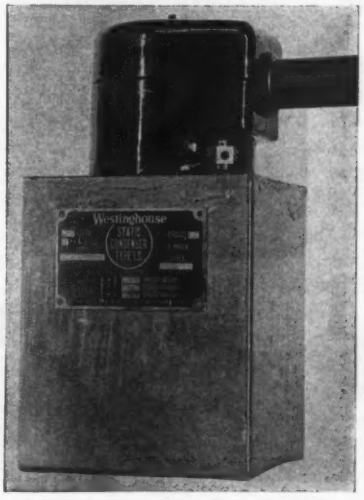
A NOVEL INDICATING device to show that the potential coils of the meter are energized has been introduced by the General Electric Company in its type D-7 polyphase watthour meter. An interruption of the potential circuit on one element of the ordinary polyphase watthour meter is not always easy to detect; a blown fuse may go undetected for some time, and in the meantime the meter registers only a portion of the power being delivered.

A few turns around the outside of the potential coil of each element serves as a transformer to energize a small, low voltage lamp on the front of the base of the meter. One lamp is used for each element. A lamp "out" means an open potential circuit, quickly detected by the meter reader or operator, and corrected with a minimum loss of revenue.

New Static Condenser for Motor Application

RECENTLY a new line of static condensers for individual motor application on motor circuits of 220, 440, and 550 v. for two and three-phase circuits has been developed by the Westinghouse Electric & Mfg. Co. The new condenser consists of insulation inclosed in a sheet-metal container and a porcelain terminal housing arranged for conduit connections.

Correction at the motor by means of these static condensers is productive of a number of advantages. Low losses of less than ½ per cent regardless of kv.a. rating; power factor correction at or very near the source as desired; improvement of voltage regulation at the motor or on the feeders due to the reduction of line current and flexible localized form of correction, are some of the outstanding advantages.



NEW STATIC CONDENSER FOR INDIVIDUAL MOTOR APPLICATION

In addition, further correction may be bought with each motor or the condenser may be changed from one motor to another. These condensers, which may be connected at the motor side and switched on and off with the motor without additional attention, may be obtained in ½, 1, 2½ and 5-kv.a. units. All live parts are completely covered, assuring safety to operators.

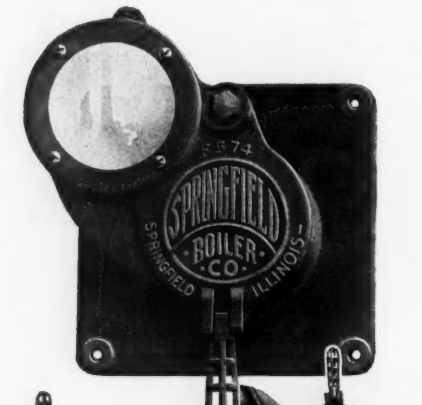
New Vapor Thermostat

DESIGNED ESPECIALLY for controlling any desired temperature range between 140 and 180 deg. F., the new vapor thermostat No. 48 has recently been placed on the market by the Klipfel Manufacturing Co., Chicago, Ill. It can also be adapted to any temperature range for application to dry kilns, gas-fired ovens, evaporators, vulcanizers and other industrial equipment requiring temperature control. The unit is constructed entirely of metal and is entirely self-contained. It operates a semi-balanced bronze lever valve by means of pressure generated by the boiling of a volatile fluid within the thermostat element, which increases the pressure on a bellows and actuates the valve. The valve is available in sizes from ½ in. up to 6 in.

Inspection of Furnace Made Convenient

RECENTLY a new peep-hole door for boiler furnaces and stills has been perfected by the Springfield Boiler Co. It is for easy installation on the fire or inspection door or to be placed on the brickwork without serious changes in the refractory lining.

This peep-hole door consists of a square plate with a 5-in. round opening and a revolving shutter having three positions: completely closing the opening; inspection position, with a special colored glass over the opening so that true conditions within may be ascertained without glare or uncomfortable heat; open, allowing the insertion of steam lance or slice bar.



SPRINGFIELD PEEP HOLE AND SLICE BAR DOOR

The new device permits inspection of furnace conditions without discomfort or eye strain, also allows working the fire without opening the large door and admitting cold air above the firebed.

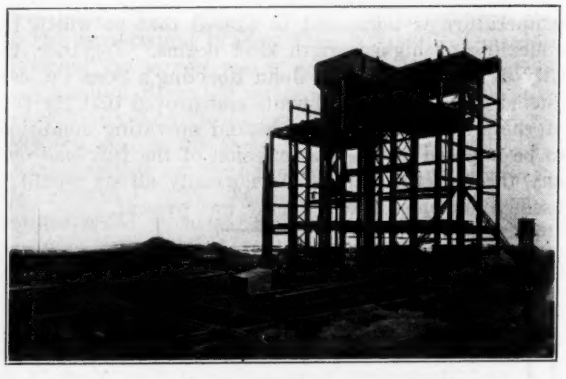
Wilson Substation Links Two Great Power Systems

WILSON SUBSTATION, new terminus of a transmission line joining the systems of the Great Western Power Co. and the San Joaquin Light and Power Corp., was formally opened on August 14.

The switch starting the power station in operation was thrown by Miss Maxine White of Bakersfield. Lester S. Ready, chief engineer of the State Railroad Commission, was the principal speaker at the dedication. The inter-connection which took place was characterized by Ready as a long step forward in the utilization of hydro-electric power on a basis as wide as the entire Pacific Coast. In addition to improving the State's electrical facilities, the new system will make available large amounts of additional water for irrigating purposes in the San Joaquin Valley.

Work Goes Forward at Bayside Plant

Construction work is progressing rapidly at the new Bayside Station of the Wisconsin Public Service Corp., now under erection at Green Bay, Wis. The accompanying illustration shows the amount of steel work erected on July 30 last. The Bayside plant is to have an initial capacity of 26,800 hp. in two generating units of equal



PROGRESS OF CONSTRUCTION AT BAYSIDE STATION, GREEN BAY, WIS., UP TO JULY 30

size. The plant is designed, however, so that additions can be made in the future. It will be interconnected with the other steam and hydro-electric plants on the system.

IMMIGRATION during the fiscal year 1925-26, the second year under the two per cent quota act, showed a slight increase over that of the previous year, but partly owing to declining emigration of aliens from the United States, our net gain in population through immigration was 13 per cent more than the previous year, according to an analysis made by the National Industrial Conference Board. The total immigration of aliens during the past fiscal year was 304,488 as against 294,314 in the previous year. Only 76,992 aliens left the United States, leaving a net gain in population of 227,496.

On the whole, quota countries during the year just closed succeeded more nearly in filling their quotas than in the previous year, due probably in large part to the better functioning of immigration administration machinery during the second year of experience with the law and its application.

A noticeable change revealed by the Board's analysis is in the migration of alien common labor. During the first year of the quota act, 15,000 more common laborers left the United States than entered, while during the past year, 43,543 entered and only 33,107 left, constituting a net gain of 10,436. Skilled labor came to the United States in greater numbers than the year before, the net gain being 47,147. Professional people continue to come in increasing numbers, reflecting the great economic pressure inflicted on this class in Europe since the war. The net gain during the past year was 9041.

THE UNITED ELEC. LIGHT CO., Springfield, Mass., has plans for a new steam electric generating plant near its present station. The new plant is estimated to cost about $1,000,000. Stone & Webster, Inc., Boston, Mass., is designing and construction engineer.

Southern California Edison Co. Finishes Florence Lake Dam

WHEN THE LAST BATCH of concrete slid through the chutes into the crest of the great Florence Lake Dam, spanning the south fork of the San Joaquin River in the high Sierras, about 100 mi. northeast of Fresno, the Southern California Edison Co. brought to completion another of its great construction projects.

This dam which crosses the river just downstream from the north portal of the Florence Lake tunnel, which was completed in February, 1925, has a crest length of three-fifths of a mile and is the longest multiple arch dam in existence. The excavation for the Florence dam was commenced in the fall of 1924. The first concrete was poured in March, 1925, and pouring continued during the summer of 1925 and up to August 13 when the work was completed. Concrete cannot be mixed and poured in the frigid altitudes of these mountain regions during the winter so that the actual building was confined to the summer months.

The dam has a maximum height above the channel of the river of 147 ft. All of the cement used in the dam was manufactured in California. The unique feature of this construction is that the rock and sand for the concrete were materials salvaged from the excavation of the Florence Lake Tunnel, consisting of hard gray granite hauled out of the dump while the tunnel was being constructed.

From the 960 acres forming the floor of the reservoir it was necessary to cut a large number of pine trees. A sawmill was set up in the reservoir site and as the trees were felled the logs were hauled to the mill by Caterpillar tractors and made into lumber. This lumber furnished most of the material used in the forms for pouring the dam and the auxiliary structures incident to building it.

News Notes

MAGNOLIA METAL CO., New York City, announces that it has moved from 113 Bank St. to 75 West St., New York City.

ON SEPT. 1, the Cleveland, Ohio, office of the Morris Machine Works, whose main plant is at Baldwinsville, N. Y., was moved to 1367 East 6th St., Cleveland.

THE AIR PREHEATER CORP., New York City, announces that Howard Butt, formerly of the Riley Stoker Corp., has joined its sales staff.

QUIGLEY FURNACE SPECIALTIES CO., INC., New York, has appointed Eagle Oil & Supply Co., Boston, Mass., as its distributors for eastern Massachusetts and Rhode Island.

L. E. FISCHER, of St. Louis, has been appointed Vice President in charge of operation of the North American Light & Power Co.

Although recently reorganized, the properties of this company will continue to be operated as a separate entity, under President Clement Studebaker, Jr., to serve the 700 communities which it supplies in Illinois, Iowa, Missouri, Kansas and Nebraska.

Mr. Fischer was the first general manager of the Illinois Traction System, serving from 1903 until 1909. Previous to that time, and after graduating from the University of Illinois, he served as assistant city engineer at Kewanee, Illinois, and as city engineer at Paris, Illinois, later becoming superintendent and manager of the Danville, Ill. electric, gas and street railway properties. Since 1909, he has been established in St. Louis as a consulting engineer on the planning, construction and operation of public utilities, and industrial engineering projects.

PENNSYLVANIA PUMP & COMPRESSOR CO., Easton, Pa., announces the appointment of Samuel Arnold, 3rd, Pittsburgh, Pa., as its representative in the Pittsburgh district.

BRIDGEPORT BRASS CO., Bridgeport, Conn., announces that its New York office has been moved from the Pershing Square Bldg. to the Farm Loan & Trust Bldg., suite 407, 475 Fifth Ave.

CHARLES T. MAIN, widely known engineer of Boston, who had charge of the exhaustive super-power survey of New England for the Associated Industries, has incorporated under the name of Charles T. Main, Inc., with capital of $200,000. Charles R. Main and Harry E. Sawtell are the other directors.

THE ROSS HEATER & MFG. CO., INC., Buffalo, N. Y., announces that Harold M. Graham and Ross H. Rathbun have joined its organization. Mr. Rathbun, who becomes sales manager, was formerly with Westinghouse Elec. & Mfg. Co., while Mr. Graham, who becomes chief engineer, has been associated with The Elliott Co.

ERNEST S. COX, manufacturers' agent for 18 companies in the Pittsburgh district, has become affiliated with the Boiler Tube Co. of America, Park Bldg., Pittsburgh, of which Marcus Boyd is president. This company sells all types of boiler tubes, specializing in bent tubes. Mr. Cox has retained the Pittsburgh agency of the Chicago Nipple Mfg. Co.

BETHLEHEM STEEL CO. has purchased from the General Electric Co. two of the largest synchronous motors, 4000 hp. at 83.3 r.p.m. and 6500 hp. at 187.5 r.p.m., for the skelp and sheet bar mill at Sparrows Point, Md. The equipment also includes a Scherbius adjustable-speed drive and a direct-current, adjustable-speed motor drive, both driven from one of the synchronous motors.

INDUSTRIAL SAFETY codes have been approved by the American Engineering Standards Committee for prevention of explosions in pulverized fuel systems and in other plants where the air might become heavily laden with inflammable dust. Also as to requirements for safe gas fitting and gas appliance installation as to fundamentals, leaving detailed treatment of particular subjects to separate specifications.

THE AUSTIN CO., Cleveland, O., has just contracted with the Reliance Elec. & Engineering Co., Cleveland, for a new 40 by 80-ft., 2-story addition to the winding department of its plant. According to The Austin Co., the steel work will be completed in 40 working days, construction having been started recently.

INDICATIONS THAT THE INSULL INTERESTS, which have acquired large holdings in Maine power companies, may build a huge steam generating plant in Portland, Me., are evident. Walter S. Wyman, president of the Central Maine Power Co., one of the Insull companies, said that probably such a plant would be built if the Insull interests obtained control of the Cumberland County Power & Light Co., which supplies power to Portland and vicinity.

Mr. Wyman also stated that an American manufacturer, now in Europe, had conferred with him relative to ability to obtain 250,000 hp. of electrical energy in some seaport city and had promised to visit Portland and possible sites in that city on his return when he learned such an amount of current was available there.

FOR FIELD USE on construction work at points remote from power lines, a portable electric arc-welding equipment is now available, consisting of a General Electric welder mounted on a Fordson tractor. The tractor is rubber tired and can make 15 to 18 mi. an hour going to the job. The welder generator is belt driven from the tractor engine.

ACCORDING TO A RECENT RULING, the City of Chicago, Ill., through its smoke inspection department, now requires users of pulverized coal to install equipment for separating fly ash from flue gas. Installations will not be approved by the smoke inspection department unless this is done.

THE NORTHERN ELECTRIC CO., operated by the Northern Paper Mills, Inc., Green Bay, Wis., has begun work on a hydro-electric power project on the Menominee River, northern Wisconsin and upper Peninsula of Michigan, designed to have an annual output of 66,000,000 kw-hr. and representing an investment of over $2,000,000.

THE NEW ENGLAND POWER CO. is negotiating for the purchase of the Connecticut Valley Lumber Co., which holds title to some 325,000 acres of land and water rights in northern New Hampshire, Vermont and Quebec. It is understood that the project involves about $10,000,000. The lumber company has some $2,000,000 first mortgage bonds outstanding and some 50,000 shares of capital stock of no par value.

It is also understood that if the New England Power Co. is successful in acquiring these properties, it will expend about $20,000,000 in development. Water powers controlled are capable of developing 100,000 horsepower.

THE BANGOR (MAINE) HYDRO-ELECTRIC CO. has purchased, at West Enfield, Maine, the largest power site and dam of the International Paper Co., according to announcement of President Edward M. Graham of the Bangor company. A $2,000,000 project will be carried out at the dam. According to President Graham, the company will in the fall start the installation of a 3500-hp. waterwheel and generator. Later 5000-hp. will be added and ultimately 15,000 hp. will be generated there. The property will be merged into the Bangor company. The site is on the Penobscot River a short distance above the mouth of the Piscataquis River and about 36 miles north of Bangor.

WISCONSIN POWER & LIGHT CO. and its associated and subsidiary companies have developed a plan to extend the connection of farms to distribution lines, at the same time bringing special reduced electric rates to farmers and making possible an economical use of electricity in the operation of all types of farm machinery. Under the new plan, the farmers of a given district will have a survey made of a locality to determine the number of possible subscribers. Upon this as a basis an estimate of the cost per subscriber will be made. If this cost averages less than a certain amount, the company will build the line at its own expense, the farmers being assessed for any expense over that amount. In return for this, each farmer will agree to invest in electrical equipment a sum equal to the cost per subscriber of building the line, to assure the use of enough power to place the line on a paying basis.

AT A RECENT MEETING, the Federal Power Commission authorized the issuance of a license for 50 yr. to the Kentucky Hydro-Electric Co., of Louisville, Ky., for a 3000-hp. water power project at United States Dam No. 7 in the Kentucky River, Mercer County, Ky. It also issued a preliminary permit for two years to the Lexington Water Power Co., Columbia, S. C., for a proposed project consisting of a dam 93 ft. high and a power house containing four 12,000 hp. turbo-generating units with auxiliaries. Power from both the above projects will be used for public utility purposes. The Commission also authorized a preliminary permit for two years to the Twin City Power Co., Augusta, Ga., for a 30,000-hp. hydro-electric project at Price's Island on the Savannah River.

APPLICATION has been filed by the Tennessee Eastern Electric Co. of Johnson City, for a power project on the Nolichucky River, to consist of three dams, one at Embreeville, one at Buckingham Ford and a third 12 mi. downstream from the company's present plant. Dams are to be 70 to 90 ft. high and total installed capacity will be 70,000 hp. Primary capacity of the stream is 12,000 hp.

THE CUMBERLAND COUNTY LIGHT & POWER CO., Portland, Me., has been authorized to retire all its outstanding bonds and mortgages and to issue $9,000,000 bonds for the purpose and for such extensions as it may make, and to mortgage its property and franchises to the Old Colony Trust Co., Boston, for the security of the bonds thus authorized. The necessary permission was granted by the Public Utilities Commission of Maine.

FOR TRANSMITTING POWER from the new Conowingo hydro-electric plant of the Philadelphia Electric Co., now under construction by Stone & Webster, Inc., 13 great transformers will step up the voltage to 220,000 v. for transmission over the 70 mi. of transmission lines to Philadelphia. These transformers, which are of the water cooled type, each with a rated capacity of 26,667 kv.a., are designed to have an efficiency of more than 99 per cent and are being built by the General Electric Co. at its plant at Pittsfield, Mass. Each transformer weighs approximately 80 t. The transformers will be arranged in four banks of three units each with the thirteenth unit as a spare. Each bank, with a capacity of 80,000 kv.a., will handle the output of two hydro-electric generators totaling 72,000 kw. per bank.

SUBSTANTIAL INCREASES in electric power production, both central station as well as industrial, are reflected in several contracts for power equipment just received by the Westinghouse Elec. & Mfg. Co. Duquesne Light Co. has placed an order for one turbo-generator of 60,000 hp. capacity, one 62,500-sq. ft. condenser with auxiliaries and three 31,400-kv.a. transformers to be installed at the Colfax Station. The Binghamton Light, Heat & Power Co., Binghamton, N. Y., has ordered one 45,000-hp. turbo-generator and three 11,765-kv.a. transformers. A third contract, received from the Solvay Process Co., Syracuse, N. Y., calls for two high pressure turbo-generators with a total capacity of 15,000 hp. to operate at 725 lb. steam pressure.

CAMBRIDGE (MASS.) ELECTRIC LIGHT CO. is erecting

an addition to its powerhouse in that city and H. R. Kent & Co., Rutherford, N. J., has the contract.

TEXAS POWER CORP., Sequin, Tex., has been formed to construct a hydro-electric project on the Guadalupe River to consist of three dams and a power station with a capacity of 10,000 hp., to be increased later.

THE PENNSYLVANIA POWER & LIGHT CO., Allentown, Pa., has arranged to buy the White Haven Light, Heat & Power Co. and the Dennison Elec. Co., both operating at White Haven, East Haven, Lehigh Tannery and vicinity.

TO DELIVER gas from the Monroe Gas Fields, into the 22-in. pipe line for the Interstate Natural Gas Co., Inc., which will extend from that field to Baton Rouge, Ford, Bacon & Davis, Inc., is constructing for the gas company, a compressing station which will contain four 1300-hp. Worthington horizontal double tandem feather valve natural gas compressors.

THE YOSEMITE POWER CO., San Francisco, Calif., has requested permission from the State Department of Public Works, California, to divert 175 cu. ft. per sec. and 65,000 acre-ft. annually from the middle and south forks of the Tuolumne River, Tuolumne County, for a hydro-electric project. Two concrete dams and three generating stations, with a total initial output of 66,000 hp., are planned.

IMPROVEMENT of the Mokelumne River in San Joaquin and Contra Costa counties, California, has been licensed by the Federal Power Commission for a period of 50 years to the Municipal Utility district of Oakland, California. The development is primarily for use in connection with a municipal water-supply project having a power house at or near the base of the dam and a transmission line of some 82 miles to the Walnut Creek pumping plant. The power capacity of the project is estimated at 9300 hp. and surplus flood waters of the Mokelumne River will be carried over a divide into the Arroya Seco reservoir pipes to be used for irrigation, flood control and other purposes.

AT ITS SCHUYLKILL STATION, the Philadelphia Electric Co. has recently installed the largest self-cooled single phase transformers that have been built up to the present time. The total capacity is 120,000 kv.a. in two banks. The complete transformers were shipped assembled in their permanent tanks, immersed in dry oil, thus eliminating the usual drying process. They are of the standard core type, circular coil construction, made by the General Electric Co. The unit rating is 60 cycles, 20,000 kv.a., 72,450 v. (Y) to 13,800 v. (delta). The equipment controls a tie line between the Schuylkill and Chester stations of the Philadelphia Electric Co. The main transformers are supplemented by separate voltage regulating transformers and because of the constant variation in power demand at the respective stations a new method of voltage control is employed involving variation of the transformer ratios and tap changing devices.

AT THE VALMONT, Colo. plant, a new turbine generator is being installed of 25,000 kw. capacity by the Public Service Co. of Colorado, thus more than doubling the capacity of the station. This will be the largest steam turbine generator between the Mississippi and the Pacific coast and will generate three-phase current at 13,000 v. which is stepped up to 44,000 and 100,000 v., for transmission lines throughout northern Colorado and those leading to Denver. The plant uses largely waste consisting of the dust and slack from mines, which is dried by passing hot fumes from the boilers through it, and is then pulverized in centrifugal mills and sent into the boiler. Steam is supplied to the turbines at a pressure of 375 lb. and a temperature of 680 deg. F., exhaust being to a 24-in. vacuum. Present coal consumption is 1½ lb. per hp-hr.

STOCKS OF BITUMINOUS COAL are about normal for this season of the year and stocks of anthracite are recovering rapidly from the effects of the strike last year, according to a survey completed as of July 1, 1926, by the Bureau of Mines. On July 1 commercial customers and retail dealers had on hand a total of 39,000,000 t. of bituminous coal. This was 3,000,000 t. more than their stock on May 1, indicating that during May and June production was greater than consumption, and coal was flowing into storage. Stocks of anthracite in the yards of retail dealers on July 1 were sufficient to last 40 days at the rate of delivery to consumers prevailing during May and June. A group of 21 by-product plants supplying gas for city use had stocks of 334,000 t. of by-product coke on July 1, as against 53,000 t. last April and 722,000 on June 1, 1925.

APPLICATIONS for the position of associate instrument engineer to fill a vacancy in the Air Service and vacancies in the Bureau of Standards must be on file with the United States Civil Service Commission at Washington, D. C., not later than Sept. 28. The entrance salary for this position is $3000 yearly. The duties are to design, develop and improve aeronautical instruments.

Books and Catalogs

FUELS AND THEIR COMBUSTION, by R. T. Haslam and R. P. Russell; size, 6 by 9 in.; 782 pages with 20 chapters of combustion text and 3 chapters of appendices; cloth; price, $7.50; New York.

To students of combustion engineering who have a thorough knowledge of physics, chemistry and mathematics this book should prove a valuable text. Almost every conceivable phase of the chemistry of combustion is discussed and there is complete mathematical development of formulas.

Bibliographies following each chapter are particularly valuable, often 10 to 20 references being given for each chapter.

In constructive criticism it may be pointed out that in view of the fact that mechanical stokers are so universally used, greater attention to detail should have been given this chapter.

It is erroneously stated that caking coals cannot be used on traveling grate stokers. Latest research on these types of stokers shows that caking coals, if properly tempered, can be burned as well as free burning coals.

PROCEEDINGS of the Eighteenth Annual Convention of the International Railway Fuel Association. Price $3; size 6 in. by 9 in.; imitation leather; 370 pages of text.

Although this book primarily discusses fuel conservation and economic methods of operation on locomotives, operators in stationary plants will derive much benefit from reading the various papers and open forum discussions. The reports of the committees on "Stationary Plants," "Storage of Coal and Oil," "Firing Practice,"

and on "Front Ends, Grates and Ash Pans," contain many valuable pointers for stationary as well as locomotive operators. There is considerable discussion of the characteristics of lignite and effective methods of burning this fuel.

THOSE INTERESTED in lighting developments will be interested in two new lighting data bulletins, LD-114C and LD-117C, issued by the Edison Lamp Works of the General Electric Co. LD-114C is devoted to the theory and characteristics of Mazda lamps and gives in convenient form much interesting information on the production of light by modern means. Effects of filament shapes, frosting, position of burning, bulb temperatures, are only a few of the many headings. LD-117C, entitled "Calculation of the Lighting Installation," explains the procedure for calculating the illumination for any given condition. It gives tables showing the foot candle requirements for various classes of service and shows distribution curves of different lamps and reflectors. Other bulletins recently issued by the Edison Lamp Works are LD-134A, devoted to the lighting of the metal working industries, and LD-108B, lighting of offices and drafting rooms.

IN A LEAFLET issued by the DeLaval Steam Turbine Co., of Trenton, N. J., the water works pumping station at Jackson, Mich., is described. Equipment installed some years ago was outgrown, although the machinery was fairly efficient and in good condition. As a result, the plant was modernized by the installation of turbine-driven centrifugal pumps, the old apparatus being retained to help out on peak loads.

LACLEDE-CHRISTY bulletin for August, published by Laclede-Christy, St. Louis, Mo., contains some interesting comments from various industries on a motion picture film prepared under the direction of the U. S. Department of the Interior, entitled the "Story of Fire Clay Refractories." This film can be obtained by addressing the U. S. Bureau of Mines, Pittsburgh, Pa.

THE PEROLIN CO. OF AMERICA, Chicago, Ill., announces that it has just developed a product called "Grossite," designed to form a "colloidal dispersoid" in boiler feed water, thus preventing the formation of scale in boilers. The action of Grossite is explained in an 8-page booklet just issued by the company.

TABER PUMP CO., Buffalo, N. Y., in bulletin 120-B discusses the design, sizes and applications of automatically controlled Taber sump pumps. These are built in single and duplex units and in capacities from 15 gal. per min. to 300 gal. per min. and for drive by all types of d.c. or a.c. motors.

WOUND ROTOR INDUCTION motors, "900 Series," types MT and MQ, are described in General Elec. Co. bulletin GEA-71-A. These are made in sizes from ¾ to 10 hp. for 220, 440 and 550 v. and are 40-deg. motors.

AUTOMATIC STATIONS is the title of bulletin GEA-90A just issued by the General Electric Co. of Schenectady, N. Y. This gives a complete list of all automatic installations made by the company up to January 1, 1926.

THE INTERNATIONAL NICKEL CO., New York City, in bulletin No. 6, entitled "Alloy Steel Reduces Die Block Costs," a 4-page letter size bulletin, perforated for binding, tabulates comparative costs of producing commercial forgings with carbon steel and nickel steel die blocks, and the savings effected by the use of the latter material. In bulletin No. 7, "Automobile Design and Automotive Steels," a 12-page bulletin, perforated for binding, the factors influencing the design of the modern motor car are treated and selection of suitable steels to be used is outlined, with typical calculations illustrating the methods used to determine the stresses and factors of safety.

DIRECT CURRENT CRANE and hoist motors, type CO-1820, made in sizes from 3 to 165 hp. and for various voltages, are described and illustrated in General Electric Co. bulletin GEA-38.

INSTRUMENTS for the measurement of temperatures, humidity, and dust content are illustrated and fully described in a catalog issued by the E. Vernon Hill Co., of 64 W. Randolph St., Chicago.

HOMESTEAD VALVE MFG. CO., Homestead, Pa., has just issued a new 24-page booklet entitled "Valve Economy." This describes and illustrates the various valves made by the company, together with many interesting applications.

L. J. WING MFG. CO., Newark, N. J., has recently published bulletin No. 36 on Wing type EM variable speed blowers. The new bulletin is written in non-technical language and explains how these blowers can be used with low pressure heating boilers to burn buckwheat coal with economy.

A 72-PAGE illustrated catalog of distribution and small power transformers, known as bulletin GEA-424, has been issued by the General Electric Co. of Schenectady, N. Y. This bulletin, which supersedes bulletin No. 45,110D, not only lists sizes and types of transformers, but also explains their construction.

IN A 4-PAGE LEAFLET, B. F. Sturtevant Co., Hyde Park, Mass., announces the Big Midget portable blower, the motor driven unit for blowing dust. It has a capacity of 45 cu. ft. per min. and is driven by a ⅙-hp. motor for 110 or 220 v. An important characteristic of the blower is that the handle is on the top instead of on the end, designed to prevent strain on the wrist when using the unit.

WEBSTER QUALITY CHAINS and sprockets are described in catalog No. 46, a strongly bound and well illustrated 96-page catalog, just issued by The Webster Mfg. Co., Chicago, Ill. This catalog gives complete description and illustrations of the various types of chains and sprockets made by this company for drives, conveyors, elevators and other service. Tables of dimensions are given, together with details of the construction.

BUFFALO FORGE CO., Buffalo, N. Y., in catalog No. 475, just issued, describes the Baby Conoidal fan. This is made in capacities from 78 cu. ft. per min. to 6850 cu. ft. per min. and in some sizes employs multi-blade wheels. In another recent bulletin, Buffalo type "FB" variable and constant speed electric blowers are described. These are designed for oil and gas furnace, for cupola work and in the smaller sizes for exhausting and similar work.

CONTINENTAL VALVE & EQUIPMENT CO. of 82 Herbert St., Framingham, Mass., is sending out a catalog on the Framanco fittings, unions, pump governors, and reducing valves. It shows the method by which these forged steel fittings are produced for working pressures of 3000 to 10,000 lb. and gives a price list and dimension table. The fittings are produced by forging from solid steel stock and have a distinguishing feature of octagon ends.